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MEDICAL ELECTRONICS

THE harnessed electron serves civilization in many powerful ways, but probably none is more far-reaching than its contribution to the art of measurement. From measurement comes understanding and thence the control of processes.

The application of electrical science, principally measurement, process control and communication, to the assistance of the medical profession for the improvement of diagnosis and the control of therapy, and occasionally for the administration of electrical treatment, is manifestly a field of service in which the members of The Institution can properly contribute.

The Council have endorsed this view and given it practical support by setting up, with the encouragement of members of the medical profession, a Medical Electronics Discussion Group as an extra-mural activity of The Institution.

The subject was brought forward through the activities of Dr. V. K. Zworykin, of the Rockefeller Institute for Medical Research, who arranged the international conference on medical electronics held in Paris in June 1958, of which details have already been published in the August *Journal*, p. 466.

The Medical Electronics Discussion Group will provide a forum in which electrical engineers specializing in electronics can meet members of the medical profession to discuss problems in which they have a common interest. The Group will hold regular meetings having the nature of colloquia, at which subjects coming within the field of medical electronics will be discussed.

The affairs of the Group will be guided by a committee broadly representative of members of both professions who are prominent in this field.

The Council feel that the second international conference on medical electronics, which it is planned to hold in 1959, is worthy of support. They have therefore agreed that the Group Committee should receive, on behalf of the Papers Committee of the international conference, notice of any papers coming from British sources.

Those interested in the activities of the Group are asked to apply to the Secretary of The Institution to be included in the mailing list for details of the Group's programme.

With so propitious a beginning, it is hoped that members will make a real practical success of the project. It is a personal challenge to each to offer his special knowledge to the community through the colloquia or discussion meetings which will be arranged and publicized.

Only a few members are wholly employed in medical work or in the biological sciences, but most at some time or other come into contact with medical problems, either personally or through the welfare services to their employees or colleagues, or through questions of public health. Through popular articles in the lay Press or television they become aware of some of the most striking medical achievements brought about by the use of specialized apparatus or measuring equipment. Often, as engineers, they may wonder why certain equipments seem to be poorly designed by their standards or why certain techniques with which they are familiar are not employed by doctors for analogous problems. The answer to these queries may be reassuring, or the criticism levelled may be justified and lead to improvements on the medical side.

In university physiological and biological research departments the workers are usually in close liaison with their colleagues in departments of electrical engineering, physics and chemistry, and on the whole they have little need for outside assistance. The same cannot always be said, however, for specialist and teaching hospitals, even when they have physics departments; for they often have only a very casual acquaintance with modern electrical-engineering methods, and so they tend to neglect available resources or to apply and perfect, themselves, electrical techniques the solutions to which may be known to some industrial electrical engineers.

The proposed discussion meetings can help to free these workers for their primary medical or biological work. As an example, a well known electro-physiologist has said on several occasions, 'It takes a year to prepare my experiments—that is, setting up amplifiers, oscillographs, recorders, frequency analysers, rate meters, flow meters, movement recorders—and only a day to perform the experiment proper!'

There are groups of medical men with problems they cannot elucidate because of the difficulties of approaching the parts of the body concerned with conventional measuring devices. Perhaps if these problems can be given an airing, non-medical engineers may be able to suggest solutions worth a trial.

There are many doctors who approach their patients with a sure knowledge of their own abilities and limitations and who

have little electrical knowledge yet feel that sensitive measuring devices may be found that will record some factor pertinent to a patient's disease and show objectively the effect of treatment. In the meetings of the Discussion Group these doctors may meet medical or non-medical specialists who can help them.

Members who may feel that the subject is a very limited one or that medical science lags behind the physical sciences in the application of modern electrical methods, may be surprised and even profitably amused at some of the ingenuity and skill which is displayed by physiological and research apparatus.

To draw the boundaries of the subject is not possible; it is the responsibility of the new committee to see that duplication is avoided and that only the real needs of the workers in this field are met, and that the value of electrical engineers to the field of medicine is brought into its true perspective in relation to the community.

SECTIONAL INTERESTS

SECTIONS WITHIN INSTITUTIONS, LIKE THE institutions themselves, admittedly are abstractions—derivatives of those individuals who constitute their membership. Only the individual member is visible, real and tangible; but his contribution of loyalty and interest is that which provides mind and sinew in the working of the group, the Section, and any such organism.

If some great and worthy object can be achieved only by the group, as happens constantly, the individual finds justification and even duty in subscribing his interest and time to the group. Usually, the smaller and more specialized the group, the more limited and special are the aims which can be pursued.

These principles, once stated, are seen to be virtual truisms, but nevertheless provide a philosophical standard with which the evolving existence of the specialized Sections of The Institution can be compared.

It would seem that the ideal of The Institution—of grouping specialists towards certain limited and particular objectives, within a united profession capable of sustaining far larger aims—is not unreasonable and is in accord with logical principles.

To keep our perception clear, it is useful for us, from time to time, to examine again those practices, those procedures, those trends within The Institution and its specialized Sections which, if taken for granted, tend to grow dull and static in the mind of the individual member.

With this in view, a series of four articles on the history, structure and work of the four specialized Sections is being prepared. The first of these, dealing with the Radio and Telecommunication Section, the oldest of the four, is published on pp. 548–550 of this issue.

The aim of these articles is, first, to inform the whole membership of The Institution, and, secondly, to reveal the Sections one to another. If the second aim is realized, it will be apparent to all that the Sections are in large measure mutually dependent. Serving one another, and the interests of The Institution as a whole, they draw strength and authority from their mutual association. Inspiration and progress, too, flourish in the cross-fertilization of ideas from Section to Section.

A practical problem which frequently arises in the pursuit of group ends is that concerned with communication. The Institution, as a corporate body, has a set of communication problems different from those of the specialized Sections.

It is with the Sections that we are concerned here, who communicate with their members along the channels of a common special and sectional interest, largely technical and scientific.

But it may be recognized that more is needed to give life to the abstraction, to call forth the assent and co-operation of the human individual in supporting the work of the great Sections of The Institution. A more direct and personal form of communication may be needed, proceeding immediately from those charged to carry forward the affairs of the Sections to their individual members.

It is evident that an auxiliary channel along which this 'person-to-person' communication could flow is to be found in the *Journal*. Circulating as it does throughout the whole membership, the *Journal* provides a unifying link for The Institution at large.

Accordingly, after due consideration, the Council recently decided to make the pages of the *Journal* available to the specialized Sections as a means of developing personal contact and communication with their members.

The use of this new channel of communication begins this month. The first *Bulletin of the Sections* will be found on p. 574, consisting principally of brief messages from the Chairmen of the Sections. It is planned to make the *Bulletin* a regular feature of the *Journal* in future.

Naturally, the best use of the *Bulletin* will be discovered by experience, but a few general ideas as to content have been developed. It is hoped to publish general announcements, notes and news for the Section members from the respective Section Committees, as well as special messages and remarks from the Chairmen as occasion requires. Reviews of the Session, prospective and retrospective, in which special attention can be directed to events of outstanding importance, will appear from time to time. Other matters which may be included in the *Bulletin* are intelligence and comment concerning Conventions; notifications regarding the election of officers and the results of these elections; and photographs and reports relating to visits, exhibitions and other events.

Reports of specialized Section meetings, which until now have been presented in *London Report*, will in future be collected in the *Bulletin of the Sections*. Short statements regarding the proceedings of informal meetings may be found desirable in some cases.

Ordinary Meetings dealing with Section papers will, of course, continue to be covered in *London Report*, though the Sections will be at liberty to make short appreciations or announcements about these meetings in the *Bulletin* also.

The *Bulletin of the Sections* is a reflection of the great and growing importance of 'the four institutions within an institution', and it will give the Section Committees a direct means of communication with their Section members. With this prologue, it is hoped that the individual member, whether or not he has yet joined the Section of his choice, will find the *Bulletin* of value and of interest, quickening his association with Section activities and encouraging his vital contribution.

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Electronic Developments in the United States

DONALD G. FINK

Is there any field in which progress is faster than in that of electronics? And what sort of a review of such progress can a man give in an hour? In the case of the lecturer after the Annual General Meeting of The Institution in London on the 15th May 1958, the answer is 'most informative and absorbing'. This is an abridged version of the original lecture, in which Mr. Fink, who is President of the Institute of Radio Engineers and director of research of the Philco Corporation, made 'a grand tour of the horizon', examining such subjects as tropospheric scatter, transistors, klystrons, masers, satellites, and radio telescopes, and paying a tribute to Britain's leadership in the last field.

Laced with such stories as that of the television engineer who confessed to a liking for incompatibility . . . between his wife and himself, for he had the income and she the 'patibility', and livened by practical demonstrations of 'whistlers', pocket radio sets, etc., the lecture presented an intriguing panorama of progress.

THE British Radio Research Station has listed no fewer than 44 000 papers and reviews published in the field of electronics since the recent war. This huge outpouring all but defies classification, let alone comprehensive understanding. I have been forced, therefore, to choose more or less arbitrarily three areas of electronic science and engineering to which particular attention and effort have been devoted in the United States during the 12 post-war years. They are: discoveries in radio-wave propagation; new electron devices; and general electronic systems, having to do with colour television, high-speed computation and radio astronomy.

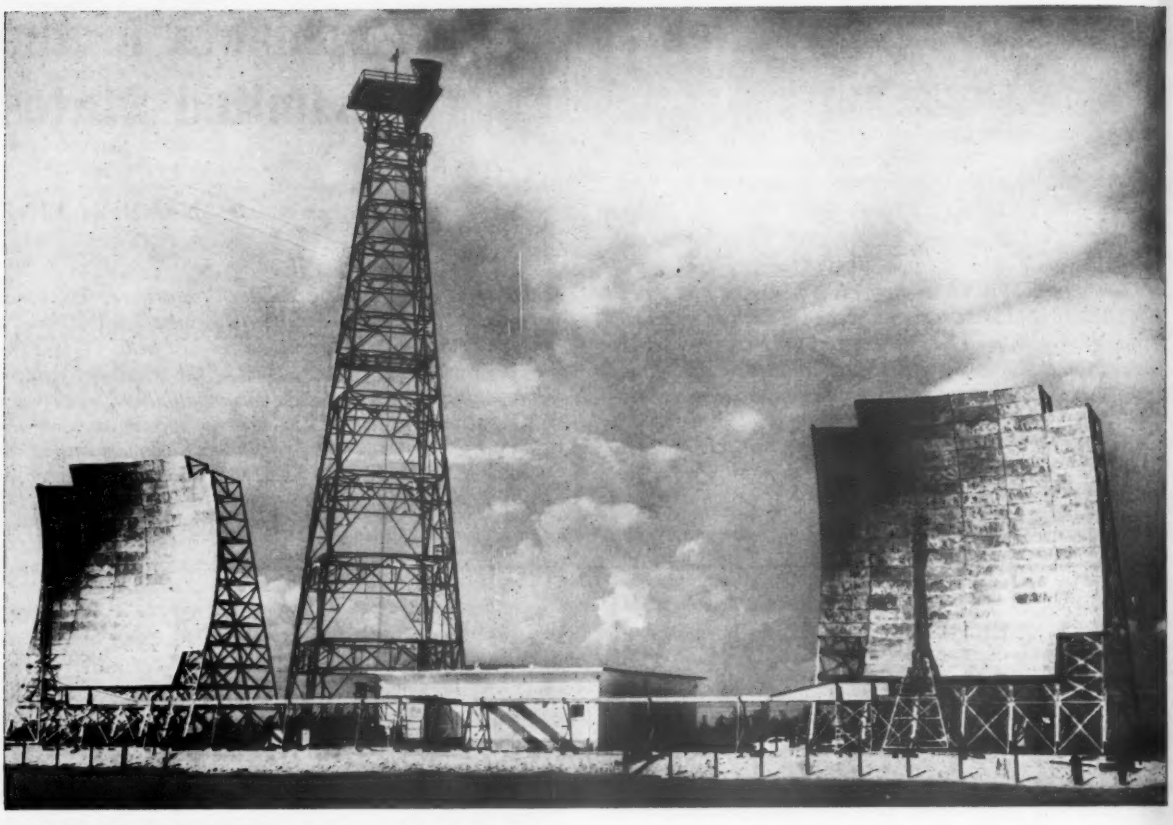
The author speaking at the Microwave Valve Convention Dinner on the 22nd May 1958

Discoveries in Radio Propagation

The central fact and abiding mystery of radio science is the passage of electrical energy through space. In 1940, after more than 50 years of patient investigation, it was a fair conclusion that the facts of radio-wave propagation had been established. But there were yet a few to come to light. During the 1939–45 War, largely as a result of radar development, radio engineers undertook to transmit greater amounts of power and to detect weaker signals, at frequencies above 25 Mc/s, than had been feasible in earlier years. As so often in the history of science, the new orders of magnitude revealed a new phenomenon. It was found that h.f. radio signals could be received occasionally over much greater distances than the current theories of propagation would predict. In retrospect, it is clear that Eckersley and Marconi anticipated these findings, but detailed study and application of them on a large scale did not take place until 1950.

The new phenomenon goes by the name of scatter propagation; it is due to inhomogeneities in the atmosphere. In ionospheric scatter, which applies to signal frequencies roughly from 25 to 100 Mc/s, a roughness of the lower edge of the E-layer of the ionosphere is believed to cause a small fraction of the radio energy impinging on it to return to the earth. In tropospheric scatter, covering the frequency range from 100 to about 10 000 Mc/s, the savants are still arguing about the precise mechanism. Some prefer the idea of local turbulence of the troposphere; others believe that the reduction of atmospheric density with height accounts for the return of a minute fraction of the transmitted energy.

Whatever the cause, scatter propagation is distinguished by a very small return of the transmitted energy, and the technology therefore requires transmitters of the highest

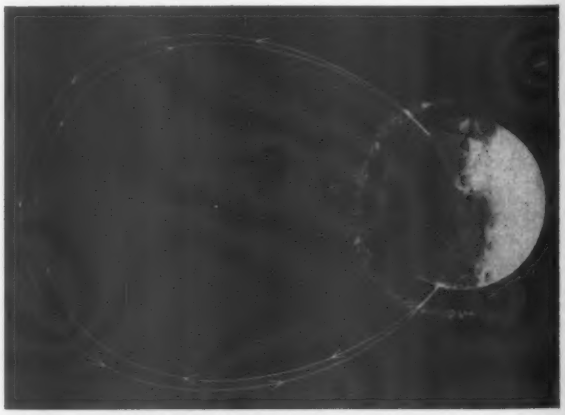


1 *Tropospheric-scatter communication system at Florida City*
The tall structure is the terminating antenna of the microwave relay system connecting with the U.S. telephone and television networks

attainable power, antennae of great size to produce high power density, and receivers of the highest attainable sensitivity. The result of taking such measures is reliable communication over distances as great as 1000 miles, at frequencies previously confined to a radius of 100 miles at the most. Most important, tropospheric-scatter propagation is suitable for television and other services transmitting information at a very high rate. Shown in Fig. 1 is a view of the u.h.f. tropospheric-scatter telephone and television installation at Florida City, Florida, which regularly connects the U.S. television network with Cuba over a distance of 185 miles.

'*Whistlers*'

At the other end of the radio spectrum, at frequencies in the audible range below 10 kc/s, renewed detailed study has been undertaken of a mode of radio-wave propagation which extends well into outer space and back again. Fig. 2 gives the explanation of the curious effect known as the 'whistler', first systematically studied by Storey at Cambridge. A lightning flash in one hemisphere of the earth generates a v.l.f. radio wave which is guided along the magnetic lines of force shown, returning to the opposite hemisphere after a transit of outer space of many tens of thousands of miles. The initial lightning impulse contains radio energy spread more or



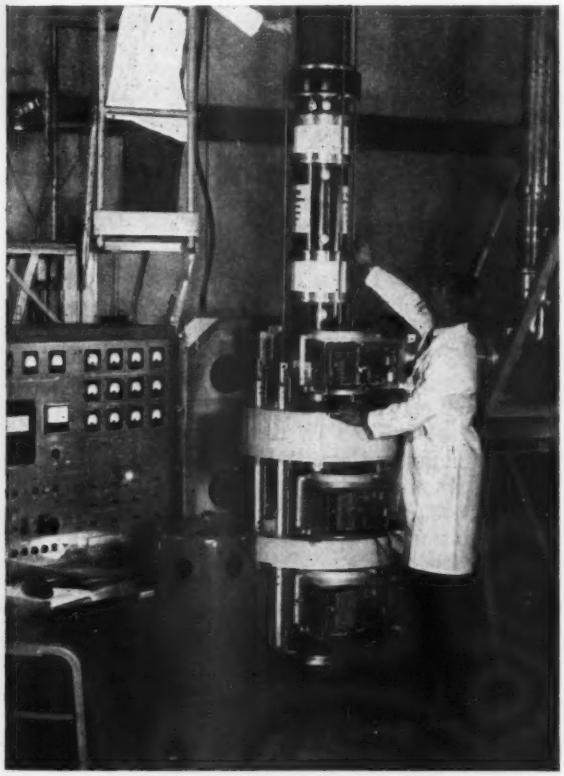
2 *The 'whistler' is a v.l.f. signal originating as a lightning flash in one hemisphere and propagated along the earth's magnetic lines of force to the opposite hemisphere*
Since the propagation mode is dispersive, the signal is heard as a tone of descending pitch, which explains the older term 'musical atmospherics', given to the phenomenon by Eckersley

less uniformly over the spectrum, but the propagation mode is highly dispersive, so the frequency content of the disturbance is spread out in time during the transit and a descending tone is heard at the receiver. The receiver is, incidentally, merely an audio-frequency amplifier of very high gain, protected from local disturbances and connected to an antenna.

Electronic Devices

Progress in electronic devices has occurred in three areas: first, in conventional vacuum tubes, in which the controlled electron stream is essentially homogeneous from cathode to anode; second, in less-conventional vacuum tubes, in which the electron stream is broken up into discrete bunches or groups, as in the klystron, the cavity magnetron and the travelling-wave tubes; and third, in new devices, like the transistor and the maser, which depend on properties of matter not previously applied in electronic devices.

The second class of vacuum tube, the klystron–magnetron family and its cousins, is an example of moulding a virtue out of a fault. The fault is the tendency of the electron stream in a vacuum tube operated at its h.f. limit to break up into groups, since at that limit the potential on the grid varies appreciably during the time



3 *The largest of the high-power klystrons, undergoing test*
This specialized transmitting valve can generate for brief periods over 1 MW at 450 Mc/s

the electrons are in transit from cathode to anode. In a conventional electron tube, the timing of this group formation is entirely unfortunate, since the potentials induced by the passage of the groups tend to cancel the signal to be amplified. The klystron has moved the family of electron devices into a wholly new range of h.f. operation, by making a virtue of bunches, i.e. by *encouraging* the formation of these groups, and by arranging the electrode structure so that the induced potentials are *in phase* with, and hence reinforce, the signal to be amplified. All the other non-conventional h.f. amplifiers (cavity magnetron, travelling-wave tube, backward-wave tube, carcinotron, etc.) employ variations of this principle, with rather startling results.

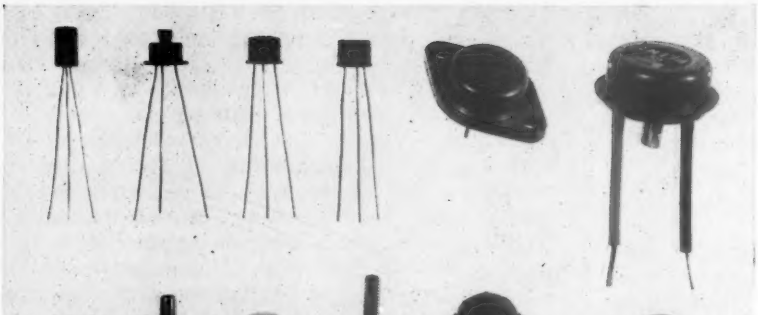
The largest of the present-day klystrons (Fig. 3) will produce an average power of 75 kW (over 1 MW for brief periods) at 450 Mc/s. Cavity magnetrons will generate microsecond pulses of 10 MW at 3 Gc/s. A travelling-wave tube will amplify simultaneously and without discrimination all signals lying within a band 6 Gc/s wide—cutting a wide swath indeed in the spectral pasture.

The third class of electronic devices comprises some strange beasts. Several of them—the transistor, the solid maser and the gyrator—contain no vacuum. Others, like the masers and atomic-beam tubes, operate without benefit of discrete charged particles and hence do not enter the strict definition of an electronic device. The transistor, the most important of them, should perhaps be called anti-electronic, since its operation depends on the controlled *absence* of electrons.

Transistors

The transistor (Fig. 4) is based on the discovery by specialists in crystallography that the passage of electricity through crystalline semiconductors is in fact a conduction of two currents of opposite polarity, although real charges of only one sign are involved. It was shown before the recent war that only one of these currents represents the usual motion of electrons, in the classical tradition of current in copper wires. The other is a current in the opposite direction, observable only in semiconductors of nearly perfect crystal structure containing specified impurities in very low concentration. This second current is due to the virtual motion of electron *vacancies*, regions in the crystal structure where electrons are temporarily absent. These vacancies came to be known as holes, and they have since taken on the aura of positive particles, just as real in the mind of the transistor designer as the electrons whose absence they represent.

The tendency of an electron to fall into a nearby hole, and thus remove itself from circulation, means that the current is highly ephemeral. But, if the hole can be made to preserve its identity for a few microseconds, long enough for it to travel from the input to the output of an amplifier, the hole current can be controlled by an external signal and amplified. Alternatively, when holes



4 *Transistors of various designs now in use in the United States*

The larger units at the right are used in car-radio sets and produce power outputs of the order of 2–5 watts in the audio-frequency range. The small unit in the centre of the lower row will generate 1 watt at 100 Mc/s. The highest oscillation frequency reported to date is 1200 Mc/s

predominate in the crystal lattice, the electron current is the transitory agent which can be amplified.

The transistor type now most widely used consists of a thin wafer of highly purified, single-crystal germanium or silicon with electrodes deposited on its faces. The third electrode is the wafer itself. The signal current to be amplified is applied between one electrode and the wafer, and the amplified signal is derived from the opposite electrode and the wafer. Unlike vacuum tubes, the transistor does not need to be heated to produce the flow of current, i.e. it requires no filament battery. It needs no vacuum and is mechanically rugged. It operates on lower voltages than comparable vacuum tubes, and it wastes much less power in maintaining its amplifying condition. It has very small dimensions compared with a vacuum tube of equal utility. Finally, and most important, the source of the amplified current in a transistor is a permanent property of the crystal structure, and the current is therefore perpetually renewable when the transistor is otherwise protected against damage. The vacuum-tube cathode, in contrast, seems doomed to exhaustion sooner or later as its surface condition changes. Hence the life expectancy of transistors, operated in suitably controlled conditions, is 10–100 times that of vacuum tubes working similarly. In view of all this, it is not strange that this tiny, rugged, efficient and long-lived amplifier has radically altered the shape of things to come in electronics.

The earliest transistors were small and efficient; but they were unreliable and confined to l.f. operation, at low power levels and small gain, compared with those of the present. Progress in the past decade has come from better understanding of the transistor's internal mechanism, which has led in turn to improved semiconductor materials with holes or minority electrons which preserve their identities for longer periods and thus permit higher gain. Further, the working frequency has been raised 100 000-fold, from a few tens of kilocycles to 1000 Mc/s, by precision in the shaping of the semiconductor wafer and in the positioning of the electrodes and by controlling the distribution of impurities in the material. The power-handling capacity at audio frequencies has been increased from a few tens of milliwatts to hundreds of watts, by refinements which permit large-area electrodes to be laid down and by clever means of removing heat from the transistor. Finally, expert metallurgy of the semiconductor and care in its subsequent processing, plus protection of the transistor surfaces by potting compounds and hermetic sealing, have resulted in transistors which can be confidently expected to perform their functions continuously, if so required, for 100 years.

Masers

Next among the post-war electron devices is the maser (this acronym is derived from 'microwave amplification by stimulated emission of radiation'). To illustrate the principle of the maser, we consider ammonia gas, which is the active constituent of the gas maser developed at Columbia University by Prof. Townes and his associates. Molecules of ammonia normally occur in a number of quantized energy states, two of which are used in the gas maser. These two states are separated by a frequency difference of 23 870 129 420 c/s. Normally, the lower of the two energy states predominates, so that if energy at or near this frequency is fed to the gas, the gas absorbs it, as a number of the molecules are stimulated to the higher of the two energy states. Later, these molecules relax to the lower state, and the energy is given off as radiation, in the random, incoherent manner typical of ionized gases.

In the maser, the molecules in the higher-energy state are sorted out of the crowd, the separation being accomplished by passage of the mixed molecules through a non-uniform electric field. A beam of high-energy-state molecules is thereby produced, which is passed into a resonant cavity before the molecules have had a chance to relax into the lower state. Under the influence of the electromagnetic forces imposed on them by the cavity, the molecules are stimulated to relax all at once, coherently; and they give up their energy in a fashion to maintain or augment the resonant oscillations of the cavity. In this manner, a signal of about 23·87 Gc/s can be amplified, with essentially no noise from the

amplifier. Note that the basic oscillatory system in this amplifier is the molecule itself, not gross coils, condensers, or cavities.

Compatible Colour Television

We turn now to our folio of selected electronic systems. No electronic system since the Second World War has received more devotion from engineers in the United States than the compatible colour-television system, and none has failed so signally to enlist public support. The fact that less than 2% of the viewing audience in the United States possess colour receivers, four full years after the colour service was inaugurated, might well argue that the system is unsound. But there now seems to be unanimous opinion, in which once-doubtful television experts in Great Britain and on the Continent concur, that the compatible colour system devised by the U.S. National Television System Committee is, in fact, the preferred method of transmitting compatible colour information, i.e. to serve monochrome and colour receivers simultaneously.

This is how the N.T.S.C. system works. In the studio, a camera containing three image-orthicon tubes and beam-splitting optics produces three television signals representative of the blue, red and green primary-colour components of the scene. These three primaries are converted in an electronic analogue-computer circuit into three other primary signals, known as the Y, I and Q primaries. The computation is based on the fact that any set of three primaries can be converted into another equivalent set by three simultaneous equations with constant coefficients.

The new set of primaries is cleverly contrived. The Y primary represents luminance and is substantially identical to the output of a standard black-and-white camera viewing the same scene. The two other primaries, I and Q, are orthogonal components of chrominance, i.e. they represent the content of the image when the luminance is removed. They have a direct correspondence with the colour qualities known to artists as hue and chroma.

The Y primary is thereupon transmitted with full bandwidth, and it serves to provide black-and-white receivers with the information to which they are accustomed. The I and Q primaries are imposed simultaneously on a subcarrier frequency (the chrominance subcarrier), and the bandwidth they occupy is purposely limited. By the use of synchronous modulation, the I and Q signals are transmitted independently. Moreover, by making the subcarrier frequency a very precise multiple of half the line-scanning frequency, the I and Q signal components are arranged in the Y-component spectrum in an interleaved fashion. The I and Q components are thereby rendered virtually invisible to monochrome receivers. Moreover, this mode of transmission introduces a minimum of interaction between luminance and chrominance and thus allows substantially independent reproduction of the three primaries.

In colour receivers, the Y, I and Q signals may be converted, by an inverse analogue-computer circuit, into the original red, green and blue primaries. This is the appropriate procedure when the colour picture tube possesses three electron beams. Alternatively, a single-beam picture tube may use the luminance and chrominance signals directly.

To summarize: the N.T.S.C. colour system derives from the real primary colours a contrived set of primaries which meets the requirements of the eye for sharpness of resolution. One of these primaries, transmitted in full detail, satisfies the monochrome-service compatibility demand. The two others are sent with restricted bandwidth and are arranged to be invisible in monochrome reception. All three primaries are transmitted in largely independent fashion over the standard monochrome-television channel.

The stage has thereby been set for a truly comprehensive colour-television service. What remains is much toil and inspiration to devise apparatus whose incremental cost matches the incremental value to the public of the addition of colour to the monochrome service.

Electronic Arithmetic

The essential elements of a digital electronic computer can be understood by considering the desk calculator. The calculator is a mechanical arrangement of toothed gear-wheels and couplings which permits decimal numbers to be added and subtracted individually and by repetition of these actions to be multiplied and divided. Essential in using the desk machine are such items as pencils and scribbling pads, tables of functions, and similar records of data. The ensemble is operated by a human being who supervises the computation, looks up and records intermediate numbers, detects errors, and follows the instructions which describe the solution of the problem before him. The corresponding parts of the electronic computer are: the *arithmetical* unit which performs the functions of the calculator proper; the *memory* which serves as the electronic scribbling pad and table of functions; and the *control system* which follows the ordained instructions ('programme') of the computation and selects among courses of action as the computation proceeds.

The electronic computer excels the mechanical computer in one basic respect: it is fantastically more rapid in its operations. Because the electronic machine can add digits at a rate of several million per second, it can handle highly complex problems, solving many complex sub-problems as it goes along; and its accuracy is limited only by the ambition of its designers in providing capacity in its arithmetical unit and memory.

Unfailing regularity of operation is an evident requirement when complicated calculations are to take place at high speed. Even a momentary failure of one switching circuit, undetected, may throw into undiscovered error all subsequent figuring. To avoid such catastrophes, three steps are taken.

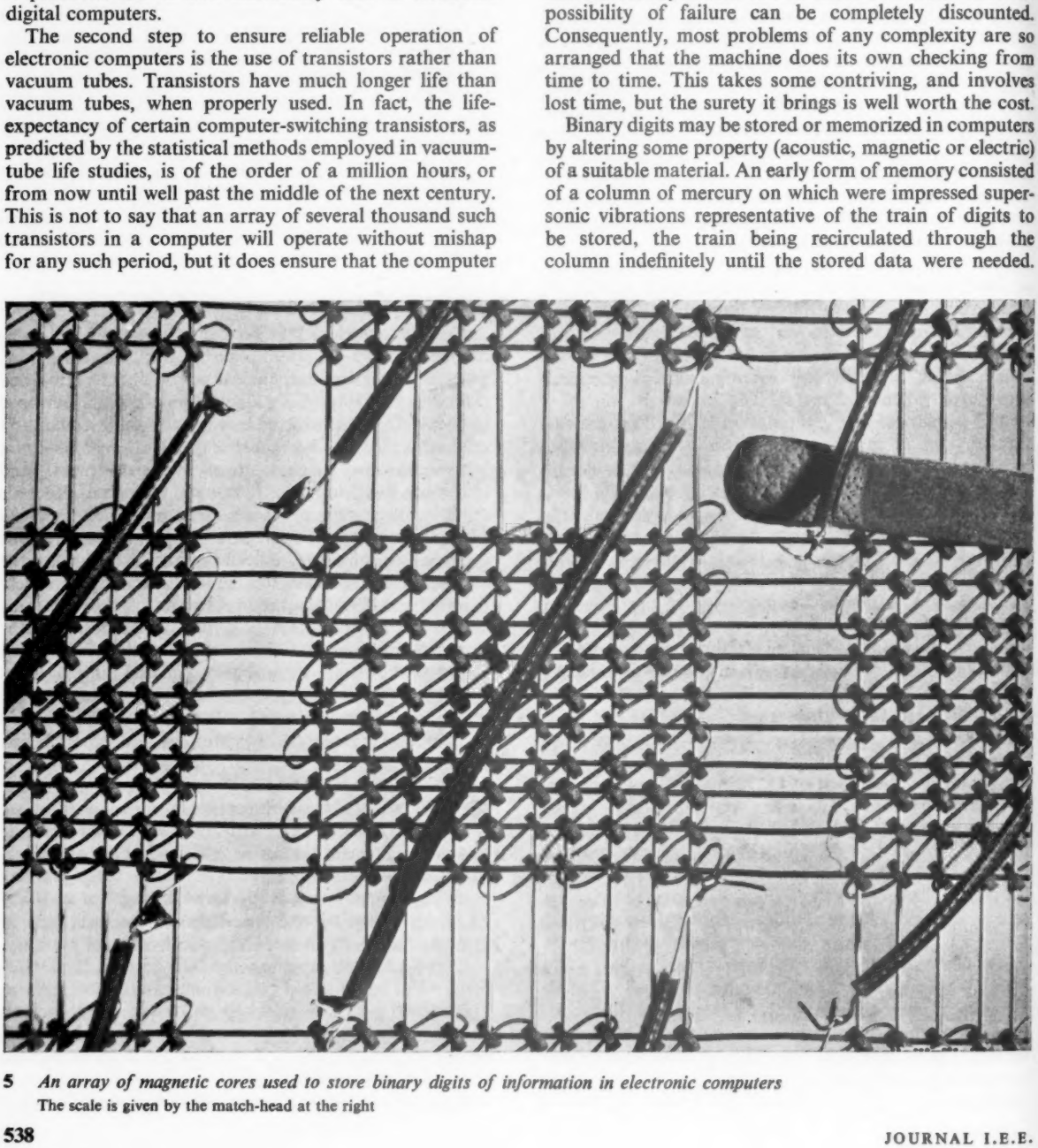
First, the electronic circuits in the computer are called

on to assume the minimum possible number of operating conditions, open-circuit and closed-circuit, or off and on, representing the numbers 0 and 1. The problem to be computed must therefore be cast in binary form, i.e. the numbers must be formed in powers of two. Binary counting involves about three times as many characters as decimal counting. But since electric circuits can distinguish between two states much more certainly than among ten states, the binary type of operation is preferred and is now universally used in electronic digital computers.

The second step to ensure reliable operation of electronic computers is the use of transistors rather than vacuum tubes. Transistors have much longer life than vacuum tubes, when properly used. In fact, the life-expectancy of certain computer-switching transistors, as predicted by the statistical methods employed in vacuum-tube life studies, is of the order of a million hours, or from now until well past the middle of the next century. This is not to say that an array of several thousand such transistors in a computer will operate without mishap for any such period, but it does ensure that the computer will operate for months with a vanishingly small probability of transistor failure. Vacuum tubes are so much poorer in this respect that they are not used in new designs of high-speed computer-switching circuits. The use of transistors also permits computers to be built in much less space and to consume and dissipate much less power than if vacuum tubes were used.

The third precaution to assure rectitude in electronic computation is based on humility, i.e. on the realization that no earthly device can be made so reliable that the possibility of failure can be completely discounted. Consequently, most problems of any complexity are so arranged that the machine does its own checking from time to time. This takes some contriving, and involves lost time, but the surety it brings is well worth the cost.

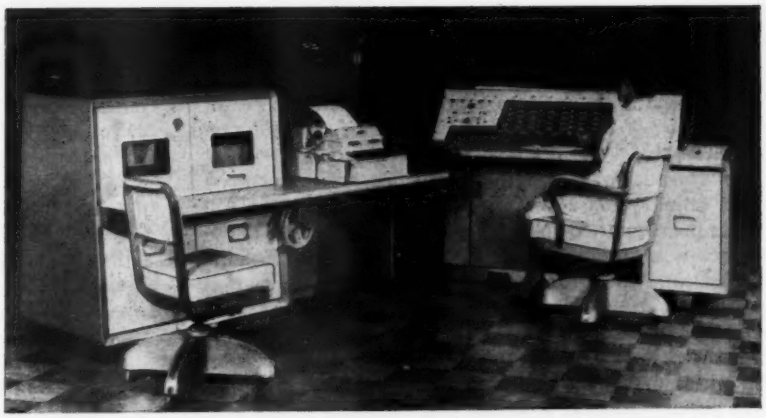
Binary digits may be stored or memorized in computers by altering some property (acoustic, magnetic or electric) of a suitable material. An early form of memory consisted of a column of mercury on which were impressed supersonic vibrations representative of the train of digits to be stored, the train being recirculated through the column indefinitely until the stored data were needed.



5 *An array of magnetic cores used to store binary digits of information in electronic computers*
The scale is given by the match-head at the right

A more recent form consists of an array of tiny ferromagnetic cores (Fig. 5), any one of which can be magnetized to represent the digit 1 and demagnetized to represent 0. Ferroelectric cores of barium titanate having two similarly stable states are also used, as are magnetic films in the shape of tape or drum.

The enormous capacity of electronic computers (Fig. 6) has rendered routine the computation, in a few days, of problems that once would have taken a lifetime of human endeavour. The problem posers have, of course, kept pace with the opportunity presented by these new machines—so much so that it remains unlikely that any electronic computing machine, however imposing its size or comprehensive its capacity, will lack problems worthy of its hire. Changes in weather, for example, are determined by physical factors, which, identified on a sufficiently comprehensive and detailed scale and subjected to computation, will permit forecasting with accuracy and prescience far beyond the present primitive attainments.



6 *The trend in design of electronic computers is toward complete transistorization, for higher reliability, smaller space and lower power requirements*
This is the first fully transistorized computer intended for use by commercial organizations

Radio and the Cosmos

From the time man first cast his eyes to the heavens until as recently as A.D. 1932, our knowledge of the sidereal universe was based on light in the visible spectrum and radiation in the infra-red and ultra-violet. It has long been known that the stars do not confine their radiation to these limited regions. Rather, in common with other incandescent objects, they radiate through a continuous spectrum which includes a feeble component in the radio frequencies. There was reason to suppose, therefore, that stars could be detected by radio, provided that large enough antennae and sensitive enough receivers could be used to detect emanations from celestial transmitters at distances of billions of miles. The random and incoherent nature of the thermal-radiation process precludes any peculiar characteristic in radio signals from the stars. One expects to hear merely a hiss or rushing sound, like that produced by the fall of water in a cataract. Despite this lack of definite character, star noise can be identified, from among all the other random noises which inhabit the radio spectrum, by the apparent rotation of the sources about the earth, in conformity to sidereal time.

In December 1932 the late K. G. Jansky reported that he had discovered a mysterious atmospheric radio noise. The next year he placed the source outside the earth, and by 1935 had localized it as coming from the direction of the Milky Way. By common consent among the investigators who followed him, Jansky thus singlehandedly founded the science of radio astronomy.

By 1946, as a result of the progress in radio science forced on the world by military events, it was possible to localize acutely the celestial sources and to record meaningful variations in stellar radio noise. New astrophysical information, unavailable to optical instruments, was thereby uncovered. Radio astronomy then took hold in a rush, and it is now a recognized and valued arm of cosmological research.

Radio observation of celestial phenomena opens new avenues in astronomy by virtue of the fact that radio waves, being many hundred thousand times longer than light waves, can penetrate regions which are blocked to visual observation. Large patches of the sky are obscured by clouds of cosmic dust, through which radio waves pass unhindered. Equally important, large regions of the universe are inhabited by gas, so tenuous as to be invisible, which in certain circumstances emits detectable radio waves. An example is the radio energy given off when two ionized gaseous regions collide.

Radio energy is not confined to the stars or interstellar gas. It has been detected from the moon, from the planets Venus, Mars, Jupiter and Saturn, from the debris of exploded stars, from nearby galaxies, from distant clusters of galaxies, from gas in the arms of the Milky Way, and from a multitude of invisible sources whose precise form cannot be established.

These findings have necessitated the use of the most advanced types of radio equipment. For example, a typical modern radio-astronomy receiver will respond to an incoming signal with an available power of 10^{-16} watt. The largest radio source identified to date, two colliding galaxies, has a power of 10^{36} watts. Radio telescopes reach out to unbelievable distances: 300 million light-years is the '*dx* record' at present for a definitely identified radio source.

The post-war effort in radio astronomy has concentrated on three main areas: (1) constructing the most sensitive receivers possible in the spectrum regions from a few hundred kilocycles to hundreds of thousands of megacycles per second; (2) the design and construction of large antennae, antenna arrays and radio interferometers

to secure the highest possible angular resolution and the greatest possible freedom from earthly interference; and (3) the development of advanced signal-processing and -recording techniques to squeeze the last ounce of significance from the feeble, featureless hisses from outer space.

In conclusion, let me quote but one achievement by your countrymen Hanbury Brown and Twiss. In 1956 these men reported that, by using widely spaced radio-telescope antennae, they had imitated the action of the Michelson interferometer, in a unique fashion that integrated out the uncertainties introduced by the electric shimmer of the earth's atmosphere, and had measured the angular diameter of the Dog Star, Sirius, to within 0·0005 second of arc, in close agreement with the optical estimate. The fact that the radio waves used for this measurement were 2·4 m long, or nearly five million times as long as the light waves used in earlier measurements, makes this confirmed result a miracle of inspired instrumentation. As techniques such as this are pushed forward, we may confidently expect that radio astronomy will plumb the reaches of space further than the most advanced optical instruments can take us.

Summary

From among many post-war electronic activities in the United States, the following have been selected for this review: scatter propagation, 'whistlers', h.f. electron tubes employing discrete electron bunches (klystron, magnetron, travelling-wave tube, etc.), transistors, masers, compatible colour television, digital electronic computers, and radio astronomy. The basic principles are described in non-specialist terms.

I.E.C. MEETINGS IN SCANDINAVIA

THIS year, owing to the very full programme, the grouped meetings of the International Electrotechnical Commission spread over three weeks, from the 30th June to 17th July, and took place in Stockholm, Västerås and Ludvika, in Sweden, and in Copenhagen. About 1000 delegates participated in meetings of 54 technical committees and sub-committees and of the Council and the Committee of Action.

At the opening of the Council meeting, Dr. Percy Dunsheath, retiring President of the I.E.C., reported the admission of four new member-countries—Bulgaria, the People's Republic of China, Rumania and Turkey—in the three years since the Council last met. The newly elected President is Dr. I. Herlitz, Chief Electrical Engineer of the Swedish General Electric Co.

The large number of technical committees covered between them a very wide range of subjects. Documents completed to the stage of circulation to national committees for comment include those on the following subjects:

Graphical symbols for valves, tubes and rectifiers; switches; measuring instruments; transmission lines and accessories; magnetic transductors; batteries and accumulators
Radiation measurements of a.m., f.m. and television receivers
Tests for performance characteristics of television receivers
Isolators and earthing switches
Miniature fuses
R.F. cables.

Documents which will now be circulated in an amended form for final approval before publication deal with:

Safety rules for radio (including television) receivers and associated equipment
Watt-hour meters
Testing of oil-filled paper-insulated cables.

As a result of the meetings, draft specifications for the dimensions of carbon brushes, reactive volt-ampere-hour meters, recording instruments and signal generators will shortly be ready for comment by the national committees.

New projects for I.E.C. attention arising from the 1958 meetings cover aluminium conductors for overhead lines, graphical symbols for generating stations, the influence of radiation on insulating materials, monocrystalline semiconductors, and h.v. measurement techniques.

Increased subscriptions

The Committee of Action forecast that next year it would be necessary to ask the national committees for increased subscriptions. Having served on the Committee for nine years, Belgium, Italy and the United Kingdom retired and were replaced by Spain, the United States and the Soviet Union. The 1959 and 1960 grouped meetings will be held in Madrid and New Delhi, respectively.

The fourth Le Maistre Memorial Lecture was delivered in Stockholm by Prof. R. Vieweg, Chairman of the German national committee. He spoke on 'Measuring—Standardizing—Producing' and showed how standardization was fundamentally based on accuracy of measurement. His conclusions were that 'technology is the effort to avoid effort' and that we standardize in order to simplify work.

Richborough Generating Station

THE Central Electricity Generating Board have received the consent of the Minister of Power to the establishment of a new power station at Richborough, Kent. The total capacity of the station will be 360 MW (480 000 h.p.), and the plant will consist of three 120 MW turbo-generator sets, together with three reheat boilers each with an evaporative capacity of 860 000 lb of steam per hour. Steam conditions will be 1500 lb/in.^{2} at 1000° F, with reheat to the same temperature. The first generating set is scheduled for commissioning in 1962.

539.17

ADVANCED REACTORS

1. Short-Term Possibilities

To select the right paths of advance in reactor development among the many possible avenues now presenting themselves is primarily the responsibility of those so charged by governments. An informed professional opinion is nevertheless of prime importance in the making of these vital decisions; and this article by the head of the reactor division of the research group of the United Kingdom Atomic Energy Authority at Harwell is to be welcomed as a timely discussion of the factors involved.

To be published in three parts, in successive issues of the Journal, the article is based on a lecture to an Ordinary Meeting of The Institution at Savoy Place on the 5th December 1957, arranged in conjunction with the British Nuclear Energy Conference.

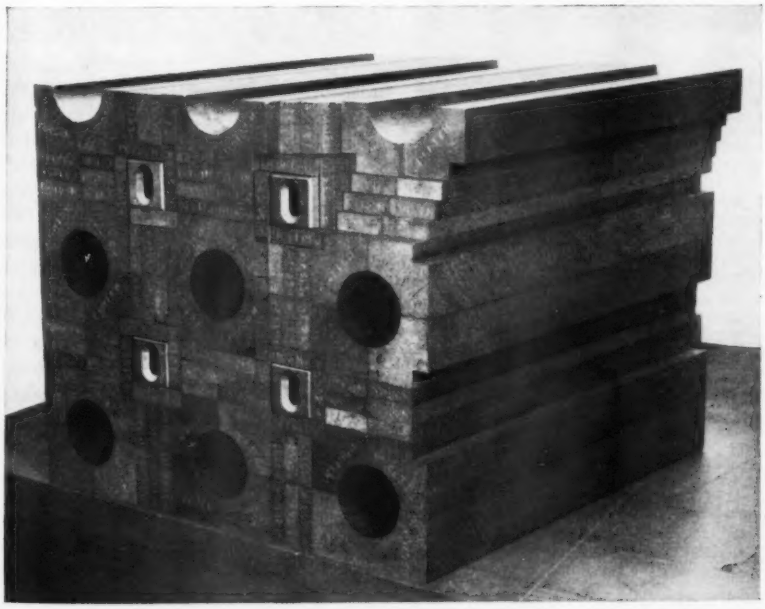
J. V. DUNWORTH, C.B.E., M.A., PH.D.,
ASSOCIATE MEMBER

WHAT is an advanced reactor? To answer this we must consider the time scale of development for the two reactor technologies so far established in the world (Table 1).

Table 1 Development of reactor technologies

	Preliminary work	Serious design study begun	Prototype complete	First commercial station
Gas-cooled, graphite-moderated	1945/50	1950	1956 (Calder Hall)	1960
Pressurized-water reactor for submarine propulsion	1945/48	1948	land 1953 sea 1955 (U.S.S. *Nautilus*)	sea 1958 (U.S.S. *Skate*)
Pressurized-water system for civil use		1949/50	1957 (end) (Shipping-port)	about 1960

Except for variants of pressurized-water technology in which boiling is permitted, there is no other system for which a full-scale prototype of a large nuclear power station is under construction at present, so far as is known. It is reasonable to regard all except the Calder Hall type and the pressurized-water type as advanced reactors, with advanced reactors based on the Calder Hall concept and boiling-water reactors coming into use during the period 1960–70. No other reactor technology is likely to be the basis of a large-scale commercial power station (as distinct from a prototype) commissioned much before 1970.



1 *Small section of graphite structure used in exponential experiment for studies of neutron reproduction*

The distance between fuel channels can be adjusted by removing the graphite slats

Massive Research Effort

It has been estimated that at least 1000 man-years of professional research and development are required to bring a new reactor technology, based on the use of solid fuel and a coolant circuit containing no fission products, to the point where a prototype reactor can be completed. Much work is needed, also, in operational studies on the prototype and in further development. Furthermore, the design and construction of prototypes call for a large engineering effort. Thus, reactor technology is likely to develop only where there is a very large scientific laboratory indulging in research and development.

If the organization is appreciably smaller, either the time scale will be unreasonably long or the laboratory will be able to carry out no more than detailed, though nevertheless very important, development of a system whose basic technology has already been established.

2 *A graphite exponential experiment in which the structure can be heated to simulate conditions in the A.G.R.*

An obvious conclusion is that only a small number of reactor concepts are likely to be developed fully within the next 20 years, since the necessary research and development effort will not be available for doing otherwise. Even the United States has begun to find itself in this difficulty and is showing signs of concentrating its programme. The head of the reactor division of the U.S. Atomic Energy Commission, Dr. Kenneth Davies, recently urged the slowing down of work on most advanced reactor systems. Instead, he asked for more effort on the pressurized- and boiling-water reactors—the only ones in which the United States was reaching larger-scale application.

A further aspect of the same situation is that even if one has a reactor system for generating electricity at, say, 0·5d./kWh, that electricity will cost about 1·5d./kWh before it reaches the ordinary consumer. Zero cost of generation would leave a charge to the consumer approaching 1d./kWh. It may be more economic to use resources elsewhere than to assemble a large staff to develop many different sorts of reactor to produce only marginal improvements in the cost of generation. Cheap nuclear power could, however, cause the development in the United Kingdom of industrial processes using electricity in large quantities and where distribution costs can be made low. Furthermore, such processes may operate at near 100% load factor, which suits nuclear power with its high capital and low fuel costs. Therefore, my argument must not be pushed too far. Nevertheless, for most industrial and private users, the cost of electricity is not a crucial item at present.

Dr. Weinberg, Director of Oak Ridge Laboratory in the United States, has stressed the importance of not diversifying too much. He pointed out something which is true of many fields of work but often forgotten: little effort is needed to start a new project but, if several different lines are started at the same time, they gradually begin to crowd one another out. While it may be easy to stop a project in the very early stages, it is much more difficult to do so when a project has gained momentum and is starting to build up in magnitude and many commitments have been made for equipment and resources. It is perhaps true of both the United Kingdom and the United States that, in the last few years, we have been passing through a period of preliminary investigation of many possible systems and are reaching a point where most of this large number of possible reactors will receive only very minor attention for some considerable time to come. Only a very few will be studied more seriously. The same has happened in the past with other new technologies.

The Immediate U.K. Programme

In the United Kingdom during the last three years, a great deal of investigation has gone into deciding on those few projects worth supporting on the large scale and for a considerable period.

The British Government White Paper of 1955 was a fairly conservative document, envisaging the development of nuclear power in three stages. Stage 1 was to

consist of the comparatively simple gas-cooled, graphite-moderated Calder Hall type of reactor; and it was expected that we should proceed fairly quickly to Stage 2, in which one still retained the concept of a solid fuel element and separate coolant. The coolant was to be a liquid, rather than a gas, to obtain better heat-transfer conditions and lower capital costs. It was believed that this would result in getting much more heat from a given size of system and thereby reduce significantly the capital cost per installed kilowatt.

Within the last two years, however, the gas-cooled graphite-moderated system has shown much greater potentialities than was anticipated, largely as a result of engineering development by the industrial consortia now associated with the programme. Pressure-vessel walls will be 3 in. or more thick, against the 2 in. maximum deemed prudent when the first Calder Hall reactor was built. This will enable larger vessels and higher pressure to be used. Minor increases in fuel temperature have been made, with a top limit at present close to 450° C. As a result, the design electrical output of 70 MW for the Calder Hall twin station has been followed by a design output in the region of 300 MW for Berkeley, Bradwell and Hunterston and no less than 500 MW for Hinkley Point.

The third annual report of the U.K.A.E.A., issued in 1957, explained that this development of the Calder Hall reactor has had two consequences. First, the programme of nuclear power has been significantly increased. The original programme called for between 1½ and 2 GW of installed capacity by 1965, with Calder-Hall-type twin-reactor stations each generating between 100 and 150 MW of electricity. It now seems that twin-reactor stations of this type will deliver at least 500 MW, and the revised programme calls for 5 to 6 GW of installed electrical capacity by 1965 or shortly afterwards.

Secondly, it was made clear in this report that selection of a Stage-2 reactor system to follow the Calder Hall type had become much more difficult, since any proposed system now faces much stiffer competition from the Stage-1 reactors. An alternative way of putting this is that Stage 1 has merged with Stage 2.

Advanced Gas-Cooled Reactor (A.G.R.)

As part of the development of the gas-cooled graphite-moderated reactor, the U.K.A.E.A. are planning to build an advanced gas-cooled reactor (A.G.R.). This will include many technological changes of existing designs (Table 2). Consideration is being given to smaller pressure vessels and higher pressures so as to increase fuel rating. Rating can be increased further by splitting the fuel bars into clusters of up to about 50 smaller-diameter bars which offer a greater heat-transfer surface. Such an arrangement also avoids high central-fuel-element temperatures which may otherwise result from high ratings and in particular avoids melting of the central core of a fuel bar. Alternatively, a number of fuel plates can be grouped together and used instead of a single solid fuel bar. Fuel temperatures can be raised by changing from uranium metal to oxide and can temperatures by changing from Magnox canning, with its temperature limitation in the 400°–500° C region, to cans made of steel or beryllium. Attention is being paid to rendering graphite less permeable and liable to chemical attack.

Most of the changes will result in lower capital costs per installed kilowatt of electrical capacity, but they will involve enrichment of the fuel. This will result in a higher capital cost for an initial charge of fuel and higher operating costs for replacement of fuel from time to time. The economic balance between these conflicting forces will be determined by experience. Paper studies will give no more than a crude indication.

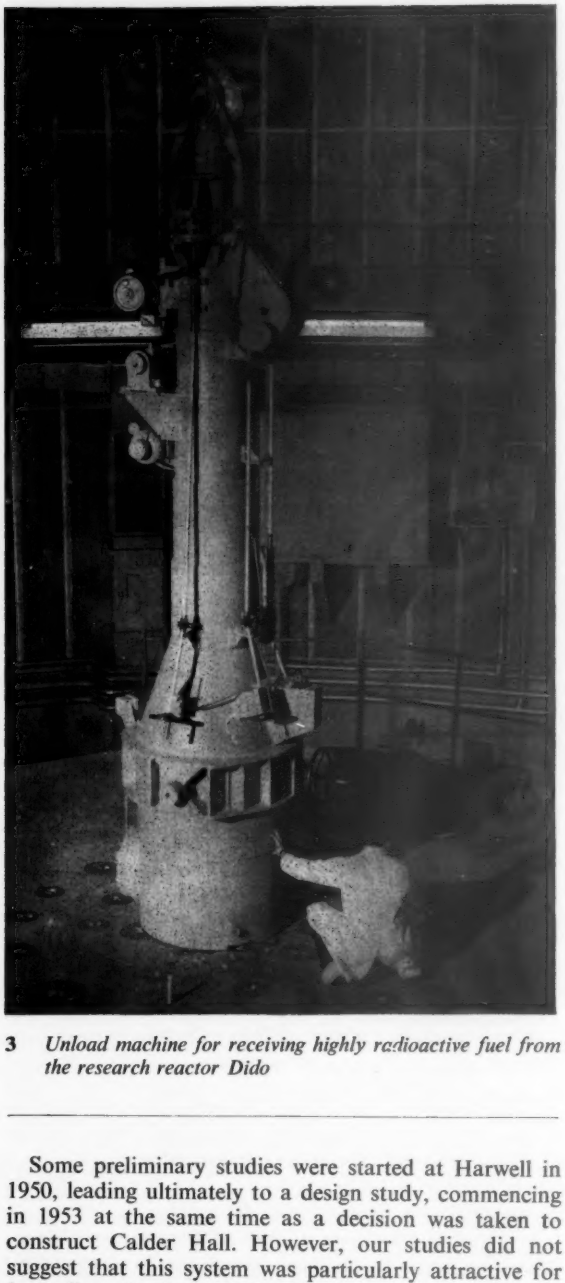
Table 2. Main parameters, performance and design data of the A.G.R.

General	
Reactor heat rating	100 MW
Net electrical output	28 MW approx.
Reactor core	
Core length (excluding reflector)	14 ft
Core diameter (excluding reflector)	15 ft
Total number of channels	250
Gas pressure at inlet to reactor	270 lb/in.² gauge
Gas temperature at inlet to reactor	250°, rising to 325° C
Bulk-gas-outlet temperature	500°, rising to 575° C
Normal maximum surface temperature of fuel-element can	600° C
Fuel and physics data	
Total weight of UO_2 fuel in core	14·6 tons
Main reactor rating	7·75 MW/ton U
Peak reactor rating	18·0 MW/ton U
Initial enrichment	1·65 C_0 (approx.)
Average thermal flux	$1{\cdot}49 \times 10^{13}$ n/cm²s
Peak thermal flux	$3{\cdot}45 \times 10^{13}$ n/cm²s
Control	
Number of control rods	25
Total reactivity absorbed	14% approx.
Engineering data	
Cylindrical pressure vessel, internal diameter	21 ft
Cylindrical pressure vessel, over-all height	60 ft approx.
Weight of moderator, including reflectors	200 tons approx.
Number of external circuits	4
Number of main circulators	4
Power of circulator coupling	1200 h.p. approx.
Charge and discharge of fuel	on load
Steam cycle	single pressure
Superheater-outlet pressure	620–670 lb/in.² gauge
Superheater-outlet temperature	860° F (460° C)
Turbo-alternator	one
Dump condenser rating	100 MW

Pressurized- and Boiling-Water Reactors

It seems fairly certain that an alternative type of reactor will still be developed for Stage 2, using a solid fuel element and either a liquid or gaseous coolant, since unexpected difficulties may arise as the A.G.R.

development proceeds. Study has been given to this problem over the last few years. The first Stage-2 system to which the U.K. gave any attention used pressurized-water technology, which both the Soviet Union and the United States have adopted for their first civil power stations.



3 *Unload machine for receiving highly radioactive fuel from the research reactor Dido*

Some preliminary studies were started at Harwell in 1950, leading ultimately to a design study, commencing in 1953 at the same time as a decision was taken to construct Calder Hall. However, our studies did not suggest that this system was particularly attractive for immediate development in the U.K., and the need for enrichment was also a deterrent. The cost in this country of providing enrichment as U235 from a diffusion plant would have been such that nuclear-fuel costs would have been comparable with, or even greater than, the fuel costs of conventionally fuelled power stations. After allowing for the higher capital charges, the over-all cost of generating electricity seemed likely to be somewhat higher than by conventional means.

Nevertheless, work continues, and the economy of a pressurized-water reactor could be greatly improved if a cheap canning material could be found. At present, zirconium is the preferred canning material for pressurized-water reactors, but it is expensive and so, too, are fabrication charges. It is possible to use steel, and although this involves a higher enrichment, the cheaper canning material offsets the dearer enrichment. Work

Table 3. Design data for experimental boiling-water reactor at Argonne

Pressure Vessel	
Diameter (inside)	84 in. (2·14 m)
Height (inside)	23 ft (7 m)
Design pressure	800 lb/in.² gauge (55 atm)
Thickness of cylindrical portion	2⅜ in. (6 cm)
Working pressure	600 lb/in.² gauge (42 atm)
Material	SA 212, grade B
Cladding material	type-304 stainless steel
Bolted-top-closure diameter (inside)	64 in. (1·62 m)
Thermal-shield thickness	1 in. (2·54 cm) stainless steel
Relief-valve setting	700 lb/in.² gauge (48·7 atm)
Total weight	approx. 60 tons* (54 430 kg)
Total weight of contained water	10 tons* (9072 kg)
Power Plant	
Condenser pressure	2½ in. Hg (0·1 atm)
Feed-water flow rate	120 gal/min (7·58 l./s)
Feed-water temperature	110° F (43° C)
Gross electricity generated	4·8 MW
Net electricity	4·5 MW
Heat sink	cooling tower
Heat transfer and fluid flow	
Average power density in core coolant	706 kW/ft³ (25 kW/l.)
Steam flow (at 20 MW)	60 000 lb/h (7·56 kg/s)
Average steam voids in heated channels	20%
Average steam voids in total moderator	17·5%
Average exit-steam quality	2·56%
Water recirculation per lb of steam	29 gal/min (1·83 l./s)
Sub-cooling at channel inlet	11° F (6° C)
Average length of core boiling	32 in.
Average heat flux	40 000 B.Th.U./h/ft² (3 cal/cm²/s)
Maximum heat flux	150 000 B.Th.U./h/ft² (11 cal/cm²/s)
Average temperature of fuel at centre line	518° F (270° C)
Maximum temperature of fuel at centre line	561° F (294° C)
Average surface temperature of fuel	495° F (257° C)
Maximum surface temperature of fuel	508° F (265° C)

* Short tons

has been proceeding for many years in the United States, the United Kingdom, and the Soviet Union on the use of aluminium–nickel alloy as an alternative canning material.

Despite the lack of immediate civil application, project work on pressurized-water reactors continued in the U.K. for the submarine application. A prototype land-based system is to be built at Dounreay, and the British Admiralty have made an approach to the U.S. Government for approval to purchase a nuclear submarine-propulsion unit from an American firm. Since last summer, the United Kingdom and the United States have been co-operating in this field of work.

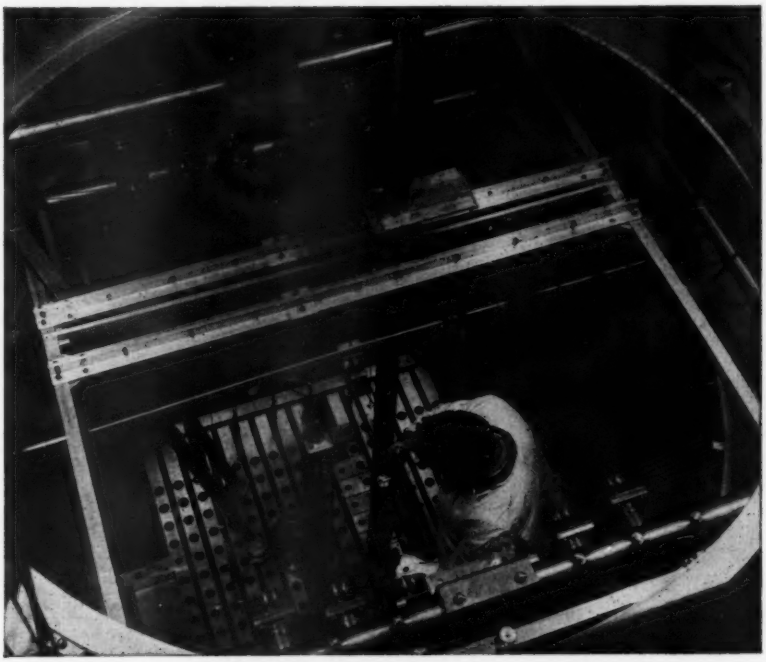
The United States has directed much attention to a variant of the pressurized-water system involving the principle of boiling. Boiling can be allowed to take place either inside the core of the reactor or only as water actually leaves the core of the reactor. In either case, steam can be passed either directly to a steam turbine or through a heat exchanger in which steam is raised separately for operating the turbine. No final view on which of all these variants is the correct economic choice is likely for some time.

A small boiling-water reactor has been built at the U.S. Argonne National Laboratory, under the direction of Dr. Zinn and his colleagues, with a design electrical output of about 5 MW from a heat output of 20 MW (Table 3). The system has exceeded expectations, and heat output has reached some 60 MW. It appears that the system has shown satisfactory stability of operation.

A small reactor of this type has also been built in California; and a larger version is under construction at Dresden, Illinois, with a design electrical output of 180 MW. Furthermore, a whole range of simple experimental reactors have been made in America to investigate the nuclear stability of boiling systems. It seems that no satisfactory theoretical design basis has yet been established.

One very important criticism made of the boiling reactor is that, if a serious fuel-element failure occurs, the turbine equipment will be highly contaminated if steam is allowed to pass directly from the reactor to the turbine. This is a question which can only be answered by practical experience. If a heat exchanger has to be used, much of the simplicity and cheapness of a boiling-water reactor is lost.

So far, water reactors have been operated on light water, partly because this was the simpler thing to do but also because it is not easy to make leak-tight a water system which is operating under high pressure, especially if steam passes directly to a turbine. However, the Argonne Laboratory intend to use heavy water in their system in due course, if adequate leak-tightness can be achieved.



4 *View looking into the tank of the zero-energy reactor Neptune*

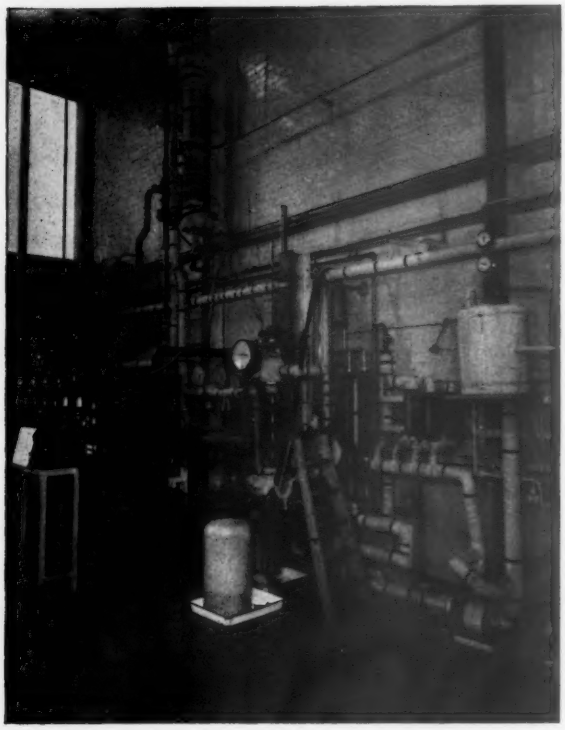
The reactor is used for studying neutron reproduction in an ordinary-water-moderated and -cooled nuclear-power plant such as is employed in submarine propulsion

Sodium/Graphite Reactor

Another Stage-2 reactor studied in the U.K. uses graphite as the moderator but sodium for cooling instead of gas. The system is technically practicable and can be built. A small experimental reactor of this type has been built in California, using inlet and outlet temperatures for the sodium of roughly 250° and 500° C, respectively. In addition, the U.S. Atomic Energy Commission have designed and operated with success a sodium-cooled, beryllium-moderated reactor in the U.S.S. *Seawolf*. However, this project is to be abandoned.

The sodium/graphite reactor meets all the problems associated with the use of sodium. For example, it is necessary to keep impurities in the coolant down to a very low level, and, in particular, oxygen must be kept down to a few parts per million. Also, sodium becomes highly radioactive, and even in one week this activity decays by a factor of 1000 only. Between two and three weeks is required for the activity in the coolant circuit to die away completely. This poses a serious maintenance problem if loss of operating time, as a result of minor defects, is to be kept to a minimum.

Another major problem in the sodium/graphite reactor is to keep the sodium away from the graphite, since sodium attacks graphite. Sodium can permeate between the layer plates of the graphite crystal structure, causing mechanical failure, and its absorption in the graphite leads also to a serious loss of neutron economy.



5 *Small heat-transfer rig, showing pipework and control panel*

The rig is being used for studies on water-cooling

As a result, the reactor design has to be based either on canning of the graphite, which is a complicated operation introducing a large amount of neutron absorption, or on containing the sodium coolant in either a re-entrant or a straight-through tube in each of the fuel-element channels through the graphite. This poses serious header problems, as well as introducing much neutron absorption into the reactor structure. Moreover, a break in any of the tubes would be quite a serious matter, because the graphite structure would be flooded.

The large amount of structural material in the core of a sodium/graphite reactor would tend to result in the system having a poor neutron economy. Also, the precise neutron economy would be extremely sensitive to the engineering design chosen. Furthermore, since the moderator of the reactor will be hot, the system will not operate to best advantage with plutonium; and it could well be that the sodium/graphite reactor will be more economical using the thorium fuel cycle than the uranium–plutonium cycle. But this is little more than speculation in our present state of knowledge.

Heavy-Water-Moderated Reactor

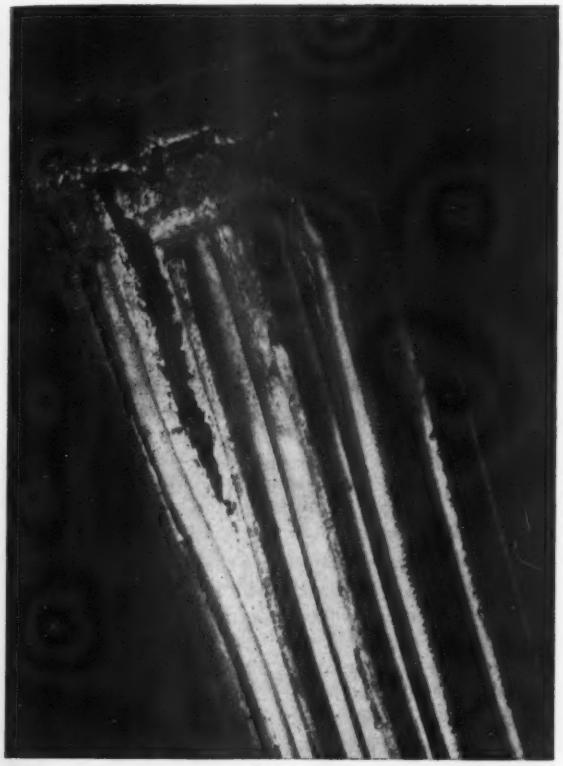
After studying light-water-moderated and sodium/graphite reactors, the U.K.A.E.A. have turned to a heavy-water-moderated reactor using a separate coolant. In particular, gas cooling is being studied at present. Such a system could use many of the techniques which have been and are still being developed for Calder Hall and its successors. Preliminary examination is encouraging.

The Canadian atomic-energy authorities have given much thought to heavy water as a moderator. They proposed a pressurized system in which heavy water was used as moderator and coolant, the whole structure being contained in a single pressure vessel. This reactor was to be known as N.P.D., but construction was halted at an early stage. Building will start again shortly with a pressure-tube instead of a pressure-vessel design. The pressure tube has the advantage that most of the heavy water can be kept cool and at high density, thus

6 *A view of Lido. The reactor core is emitting Cerenkov radiation*

The reactor is suspended in a pool of water from a movable platform on which is located the control panel

improving the neutron economy. The development of a reactor with a larger total output than that from the pressure-vessel design should be facilitated, since, with the pressure-tube design, there is no over-all limit to the size of system.



7 *Uranium-metal fuel is protected from chemical attack by means of an aluminium can in the early U.K.A.E.A. reactors such as Bepo*

The illustration shows oxide formation caused by an artificially induced failure of the can

It is still too early to predict the outcome of research on heavy-water systems, but a great deal of attention is being paid to them in a number of countries. Many coolants are under consideration, including light and heavy pressurized water, boiling water, steam, carbon dioxide, organic liquids, and sodium.

Other Stage-2 Reactors

Although other Stage-2 reactors are feasible, e.g. based on the use of beryllium moderation or on the water-cooling of a graphite reactor employing pressure tubes, it is believed that the systems mentioned are those to which most attention is likely to be devoted in the next few years in the various countries with a live nuclear-power programme.

Education and Training of Student Apprentices

A NEW REPORT

OUR rapidly advancing science imposes on every electrical engineer a new duty of keeping in touch with the evolutionary changes that occur in the methods of educating and training his successors. The mature electrical engineer will recall with nostalgia, if he was fortunate enough to attend university, his comparatively leisurely student days. If he was not so fortunate and educated himself by part-time study he will recall the tiring evenings at classes after a long day at the bench. Both these types of engineer have made an equally important contribution to the development of the science and art of electrical engineering as it is today. Together they have forced the advance of electrical engineering to a point where the university student is pressed for time to devote to ever-extending depths of study. The part-time student finds himself, alas, involved in an arduous and lengthening period of study. It is only the traditional 'intestinal fortitude' of the part-time student which makes his route to professional qualification possible at all.

The recently published* Report on the Education and Training of Student Apprentices stresses a preferable alternative for the part-time student. This is the industry-based sandwich course in which the student spends alternate periods of six months for four or five years at a major college of technology and the remaining period undergoing concentrated and integrated practical training with his employer. This scheme should allow a student to attain the educational standard associated with a university-degree course without losing the intimate knowledge of the shop floor for which the part-time student has so rightly been noted. Some sandwich courses will qualify the successful student for the Dip.Tech.(Eng.)—the sandwich alternative to an honours degree. The Report emphasizes that the success of a sandwich course is dependent on close collaboration between industry and the technical colleges so that the students' education and training can advance hand in hand. The extended period at a technical college allows a measure of liberal studies to be taken into the curriculum, thus encouraging the development of the whole man and fitting him for posts of the highest responsibility within industry.

As the years unfold, two parallel columns of student engineers will emerge. First, the university men with their post-graduate practical training, and second, the student apprentices with their concurrent training and education in a sandwich course. A smaller group who, by force of circumstances, are unable to avail themselves of the opportunities offered by sandwich courses will continue to follow part-time studies. It is one of the responsibilities of chartered electrical engineers to see that the man of promise is diverted from this arduous and protracted part-time route to the sounder and more stable sandwich course demanded by professional standards at the earliest possible stage in his career. The Ordinary National Certificate will be a useful stage at which to detect the prospective professional engineer.

* 'The Education and Training of Student Apprentices in Electrical Engineering', a Report of the Joint Committee on Practical Training in the Electrical Engineering Industry. The Committee is appointed by the Council of The Institution in consultation with the public utilities and the trade associations representative of the electrical-engineering industry in the power, electronic and telecommunication fields. The Report, which is obtainable on application to the Secretary of The Institution, costs 2s., post free

The Four Pillars of The Institution

1. THE RADIO AND TELECOMMUNICATION SECTION

THE whole field of electrical engineering falls naturally into four parts, which are always clearly distinguishable from any viewpoint; they have been named by The Institution in the titles of its four Sections—Supply, Utilization, Measurement and Control, and Radio and Telecommunication. Any account of the work of these four institutions within an institution must begin with the last, for it is the oldest and the one which continues in direct line of succession the activities which prompted the founding of The Institution in 1871 as The Society of Telegraph Engineers, a description of those concerned in the first public use of electrical engineering. Telegraphy flourished and became the ancestor of the modern techniques, which now embrace the whole field of telecommunication, navigational aids, and the related electronic applications in science, medicine and industry. These have continued to claim a major share in the activities of The Institution as a whole.

Telegraphy was the basis on which The Institution was founded; subsequent developments in the field of power supply and transmission, and in the utilization and measurement of electricity, through which the range of electrical engineering spread, made it desirable, in 1888, to rename the original Society by the title which it has used ever since—The Institution of Electrical Engineers.

Unity in Diversity

It has always been one of The Institution's major duties to provide for the rapid and orderly release of new information on all aspects of electrical engineering, and at the same time to give its members who specialize in a particular branch convenient opportunities to discuss their specialities. By the formation of its specialized Sections, The Institution has met these apparently divergent needs and by preserving in a single Institution the representation of the whole of the electrical-engineering profession has given the specialist unique opportunities of association with others working in related fields.

Even before 1900, three papers, by Sir Oliver Lodge, Sir William Preece and Senator G. Marconi, represented foundation stones in the establishment of practical radio communication. Another early paper of outstanding interest is that by W. Duddell and J. E. Taylor, which can still be regarded as a classic in the study of the propagation of electric waves over the sea. Earlier still, in 1892, Nikola Tesla had given a demonstration lecture, which was doubtless of a most spectacular character, on the applications of h.v. transformers operating at up to megacycle frequencies; while papers by Sir Ambrose Fleming, Dr. W. H. Eccles and others established the groundwork of quantitative measurement in the various branches of radio technique.

In 1919, the Wireless Section was set up, the material first presented before it being to a large extent surveys of the development of radio communication in the Armed Forces during the 1914–18 War; and for 25 years thereafter the *Journal* of The Institution provided a comprehensive record of the progress of radio engineering and research in all their various branches and preserved in a permanent form the specialist papers read before the Wireless Section. The growing importance of this function was recognized by The Institution when, in 1926, the *Proceedings of the Wireless Section* was established as a separate feature, meeting a real need and representing one of the most valuable facilities offered to the members of the Wireless Section of those days. It was the direct ancestor of the present Part B of the *Proceedings* of The Institution.

Silver Jubilee

On the 3rd May 1944, during the Second World War, the Wireless Section celebrated its Silver Jubilee and held a commemorative meeting at which addresses were given by its Past-Chairmen. The Jubilee was marked by a change in the name of the Section from Wireless Section to Radio Section, a title which it preserved until 1955, when line communication was added to its scope and it was given the name which it bears today, the Radio and Telecommunication Section. Perhaps the deference and respect paid to The Institution's founders had contributed to the determination to preserve telegraph and telephone engineering as a general activity of the whole Institution for, some may say, too long; be that as it may, the science and art of all electrical communication had become by then so indistinguishable in application that the merger was inevitable. This process of evolution shows how much The Institution is a living body, capable of growing, subdividing and recombining to meet the needs of its members.

The list of the names of the Chairmen of the Section since 1919 is an epitome of progress in the radio art, so many of the holders of this office having left their mark on the development of radio and communication engineering. The Section has always been a fertile source of future Presidents of The Institution; since 1919, no less than 14 Presidents have come from the light-current field, of whom eight had previously been Chairman of the Section.

In the course of its recent session, from October 1957 to May 1958, 16 meetings in the normal programme of the Section were held, eight devoted to the presentation and discussion of papers and eight being informal

evenings at which topics of current interest are discussed, as for example 'An enquiry into the specification of transistors' and 'Stereophonic recording on gramophone discs'. The average attendance at these meetings was over 230. This, the normal programme of the Section, does not always suffice to present in adequate detail a record of advance in a particular field, and recourse is had to additional technical conventions.

Conventions

After the recent war, the Radio Section arranged for the orderly release of information—much in arrear for reasons of security—on the classic wartime work on radar and allied techniques and on radiocommunication. Two large conventions were held—the Radiolocation Convention in 1946 and the Radiocommunication Convention in 1947. The proceedings of both these conventions were published in two special volumes. Since then it has arranged in 1952 a Convention on the British Contribution to Television; in 1955 the Convention on Digital-Computer Techniques, in collaboration with the Measurement Section and the Department of Scientific and Industrial Research; in 1957, again in collaboration with the Measurement and Control Section, a Convention on Ferrites; and in 1958 a Symposium on Long-Distance Propagation above 30 Mc/s, a Convention on Radio Aids to Aeronautical and Marine Navigation and, lastly, over a period of a full week, an International Convention on Microwave Valves, for which there were over 700 registrations, by no means a record.

During the recent session, 257 papers were submitted to the Section Committee, of which 185 were accepted. Of these, 109 were included in the conventions and symposium; of the 76 papers in the regular programme, 15 were read and discussed at meetings of the Section, 61 papers being published in the *Proceedings* without previously having been read.

Today, the Section's papers dealing with radio and light-current technology represent more than two-thirds of the contents of two parts of The Institution's *Proceedings:* Part B—Radio and Electronic, including Communication, Engineering, and Part C, which contains monographs of particular interest to specialists.

It is indicative of the high degree of autonomy which the Specialized Sections of The Institution enjoy, and their flexibility, that the Radio and Telecommunication Section Committee, with the Council's support, were able to act quickly after the launching of the first earth satellite and to convene a meeting at which the radio techniques employed in its tracking were discussed. The date of the meeting, the 22nd November 1957, fell opportunely, as, in the interim between announcement and convening, the second Sputnik was launched, and contributions concerning it were included in the same meeting.

So great is the pressure to discuss and record details of new discoveries in telecommunication research, and of practice in their application, that the Committee of the Radio and Telecommunication Section have made plans for the holding of further conventions extending already as far as May 1962. Thus, in January 1959 long-distance transmission by waveguide will be discussed; during spring 1959 the holding of a symposium on stereophony is contemplated; in May 1959 there will be a full international convention, with an exhibition, on transistors and associated semiconductor devices, to be followed in the next session by a symposium on electronic telephone exchanges; in 1960 there will also be a full-scale convention on materials and components in communication and electronic engineering, carrying further the record of technical progress given at the Convention on Ferrites in 1957. In May 1961 there is to be a convention on radio and line communication and in May 1962 a convention on television.

Regulations and Relations

It is not surprising that the richness of this work has contributed to the Regulation and Code drafting activities of The Institution. Since the early 1930's The Institution has been the focus of the investigations into radio-interference problems, through a fully representative committee, ably chaired for many years by the late Sir Clifford Paterson. Springing from this are the special duties imposed on The Institution by the Wireless Telegraphy Act, 1949. There is much other activity in the preparation of Codes and Regulations dealing with services on land, at sea and in the air, an example of the latter being Section R—Radio—of the British Civil Airworthiness Requirements.

Through its active participation in the Conference of Engineering Societies of Western Europe and the U.S.A. (Eusec) and in the Commonwealth Engineering Conference, The Institution itself provides its members in all four Sections with special facilities and privileges mutually offered by the societies participating in these conferences, and close international co-operation has been developed in this manner. In addition, each Section may develop for itself some special relationship with another body with like interests in another country; in this way the Radio and Telecommunication Section has a joint liaison committee with the Institute of Radio Engineers of America and has friendly relations with the Société des Radioélectriciens. The Institution's close connection with the Union Radio Scientifique Internationale is also effected through the Section.

The Electronic Link

What, then, is this Radio and Telecommunication Section of The Institution which is so prolific in its treatment of matters falling in the light-current electric and electronic field? It comprises some 6000 members of The Institution who have established that their professional interests lie in its sphere by applying formally to be inscribed as members of the Section. It is also noteworthy that the membership of the Section comprises virtually only those who are professionally

qualified, either as Corporate Members or as Graduates; though the latter hold an academic qualification, they have still to complete The Institution's requirements as to training and responsible experience before becoming Associate Members, but they are nevertheless expert in this field of electrical engineering. Membership by those in the grade of Students of The Institution is not encouraged, for the Council are alive to the dangers of too early specialization.

The wheel has turned full circle. Early telecommunication brought The Institution into being, and its modern counterpart, often called electronics, now bids fair to become the pivot or common link vitally strengthening all four Sections. Communication, control, measurement and computation, all basically electronic, essentially serve the other three parts as they in their turn serve Radio, Telecommunication and Electronics, the true description of the oldest Section.

CORRESPONDENCE

HISTORY OF ELECTRICAL ENGINEERING

From J. W. HIBBERT, ASSOCIATE MEMBER

ON p. 298 of the June *Journal*, George Westinghouse (1846–1914) is referred to as the inventor of the vacuum brake. Maj. L. H. Peter, in the August *Journal* (p. 436), states that Westinghouse invented the compressed-air brake.

Both the compressed-air brake and the vacuum brake are sometimes thought of as American inventions. According to the *Railway Magazine* for October 1897 (p. 383), both types were invented in Great Britain when George Westinghouse was but a two-year-old infant. The magazine said:

Both the compressed-air and the vacuum brakes have usually been considered American inventions. This, however, is not the case. Lord Masham has recently called attention to the fact that he patented both ideas as long ago as 1848, or 21 years before Westinghouse entered the field. The Westinghouse brake was not patented in America until the 13th April 1869. Lord Masham's patent is No. 12029, and the following description of the invention was published in an engineering magazine in 1848—forty-nine years ago:

'Railway brakes.—Samuel Cunliffe Lister of Manningham Hall, Bradford, gentleman, for improvements in stopping railway trains and other carriages, and generally where a lifting power or pressure is required. Granted January 18th, enrolled July 18th, 1848. In this railway brake the resisting force is atmospheric pressure or the pressure of compressed air, bearing against the brakes, which, as usual, act on the circumference of the wheels. The apparatus consists of an air chamber placed below the framing of the carriage. It is provided with a piston or pistons, to the rods of which are attached the blocks, bearing against the wheels. The air is condensed into the air-chamber by air-pumps, worked by the axles of the carriages, and, by means of the pistons and rods, the pressure is communicated to the wheels. The mode to be adopted when the brakes are required to be thrown into action is for the guard, by means of suitable connecting apparatus, to open the valves, by which means the atmospheric air will be admitted to the pumps, a few strokes of which will then so compress the air within the receiver as to press the brakes against the wheels. Similar effects are produced by making the pumps act as exhausters instead of compressors.'

GEORG SIMON OHM AND HIS LAW

From H. R. J. KLEWE, DR.PHIL., MEMBER

WITH regard to the controversy about the birth year of G. S. Ohm (August *Journal*, p. 436), a German publication for the 150th anniversary of his birth gives the date as the 16th March 1789, with the remark that the frequent, but erroneous, quotation of the year 1787 is probably due to an error on Ohm's tombstone in Munich.

The full title of my source is:

Georg Simon Ohm als Lehrer und Forscher in Köln, 1817 bis 1826. Festschrift zur 150. Wiederkehr seines Geburtstages. Herausgegeben vom Kölnischen Geschichtsverein in Verbindung mit der Universität und dem Staatlichen Dreikönigs-Gymnasium in Köln.

It was in Cologne that Ohm, as a teacher at this grammar school, made the investigations leading to his law.

M.K.S. UNITS—THE STRUGGLE AVAILETH

From C. S. JEFFREY, MEMBER

I WAS very interested in the Foreword in the July *Journal* (p. 349), but I wonder if members realize how long the struggle has been going on. Rankine wrote this song about it in 1864:

THE THREE-FOOT RULE* (Tune, *The Lincolnshire Poacher*)

When I was bound apprentice, and learned to use my hands,
Folk never talked of measures that came from foreign lands;
Now I'm a British workman, too old to go to school,
So whether the chisel or file I hold, I'll stick to my three-foot rule.

Some talk of millimetres, and some of kilogrammes,
And some of decilitres, to measure beer and drams;
But I'm a British workman, too old to go to school,
So by pounds I'll eat, and by quarts I'll drink, and I'll work by my three-foot rule.

A party of astronomers went measuring of the earth,
And forty million metres they took to be its girth;
Five hundred million inches, though, go through from pole to pole,
So let's stick to inches, feet, and yards, and the good old three-foot rule.

The great Egyptian Pyramid's a thousand yards about,
And when the masons finished it, they raised a joyful shout;
The chap that planned that building, I'm bound he was no fool,
And now 'tis proved beyond a doubt he used a three-foot rule.

Here's a health to every learned man that goes by common sense,
And would not plague the workman on any vain pretence;
But as for those philanthropists who'd send us back to school,
Oh, *bless* their eyes, if ever they tries to put down the three-foot rule!

I well remember that when I entered Lord Kelvin's workshop as an apprentice in 1897 I was instructed to buy and use a steel rule calibrated in centimetres and inches. I have been familiar with the C.G.S. units all my working life, but that centimetre rule was the only one I ever used in a workshop. I wish The Institution every success in the struggle, but I would that a few could write verses like Rankine and Clerk Maxwell.

* Rankine, W. J. MacQuorn, 'Song of the British Association 1864' (Rankine Songs and Fables, 1874)

'ON THE ROAD' WITH THE FARADAY LECTURE

The 1957–58 Faraday Lecture was, among other things, a remarkable feat of showmanship, bringing to layfolk all over the country a deeper appreciation of the electrical engineer's contribution to that burning topic of the day, the electrification of the railways.

Mr. Ledger, who took over the task of the Faraday Lecturer, the late Mr. G. H. Fletcher, is with the General Electric Co. Ltd. Brief reports of four of the presentations of the lecture appeared in the Journal for April (pp. 220, 222) and May (p. 282).

R. LEDGER, B.SC.TECH., ASSOCIATE MEMBER

THE Faraday Lecture was instituted in 1924 to commemorate Michael Faraday's pioneer work in electrical engineering. It is a particularly appropriate way of doing so, because Faraday was, in addition to his other accomplishments, a great lecturer. The Lecture explains the basic principles of some branch of electrical engineering to audiences drawn from the general public.

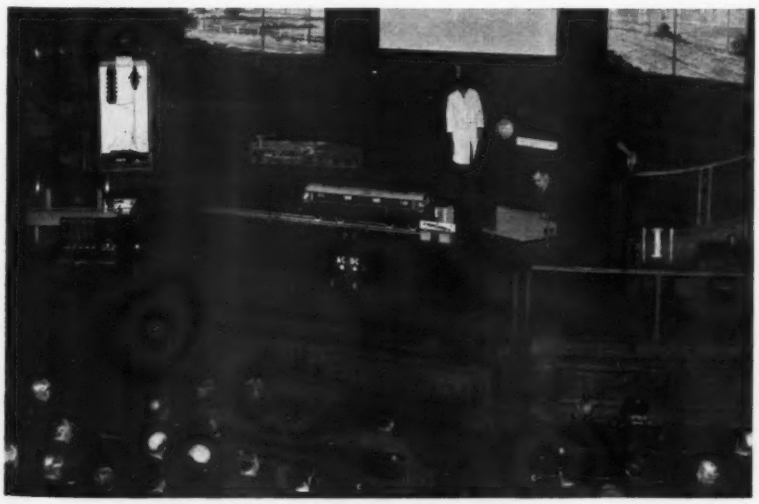
The 1957–58 Lecture, the 29th in the series, was prepared by the late Mr. G. H. Fletcher, who unfortunately died suddenly after he had delivered the first three lectures. Mr. Fletcher had worked extremely hard for over a year preparing the Lecture, and it was particularly tragic that his death should occur after he had successfully given the first three lectures and had thus completed the hardest part of his task.

The delivery of the remaining lectures was taken over, at the request of The Institution, by myself. I had assisted Mr. Fletcher in the later stages of the preparation work and in the presentation of the first three lectures.

Content of the Lecture

The Lecture was entitled *The Electrification of Railways* and opened by describing the programme of British Railways, which is a typical example of work being carried out in many countries. The difference between alternating and direct current was demonstrated, and a comparison was given of the various types of electrification to show why the 25 kV standard-frequency system has been adopted for future electrification in Great Britain. The construction of typical d.c., a.c., and Diesel-electric locomotives was illustrated by means of a $\frac{1}{8}$th-full-size model which could be quickly converted from one type to another. A demonstration of the basic features of traction-control equipment was given by means of a master controller and contactor panel regulating a model traction motor.

Some of the economies resulting from electrification were mentioned, and the advantages of using electric multiple-unit stock for local services were brought out in a film. The merits of main-line electrification were stressed in another film comparing steam and electric operation on the Manchester–Sheffield–Wath lines. After a mention of the use of electricity in the modernization of signalling installations, there was a display of the principles and operation of an automatic train-control system which gave audible indication to the driver of the aspect of the distant signal and stopped the train if its warning was ignored when the signal was at caution. Finally, a film explained the electrification of the French Railways line between Valenciennes and Thionville, using the 25 kV a.c. system.



The Lecture in progress at the Central Hall, Westminster

Travelling Circus

Because it is intended for a general audience, the Faraday Lecture is quite different from other lectures and papers of The Institution. It must be simple enough to be understood by non-technical listeners and yet should be of interest to engineers who are not specialists in the particular subject. Consequently, much use is made of demonstration equipment. With the installation and operation of this equipment, the presentation of the lecture, far from being a one-man affair, becomes what has been aptly described as a sort of travelling circus.

No one who has not been actually concerned in the presentation of a Faraday Lecture can have any conception of what it is like. I had the unusual experience of starting as a stage manager and finishing as a lecturer, and so have seen all sides of the job. The 'circus' consisted of nine people, eight demonstrations, backcloths, tables, lecturer's desk, lighting equipment, films, slides, sound and projection equipment, telephones, signal lights, and one enormous box labelled 'spares' which was almost a complete ironmonger's and electrician's shop. The circus wagon was a 3-ton removal van.

The various halls at which the lecture was presented had been inspected beforehand, and details of the greatly varying layout of stage, lighting and sound equipment,

One of the simpler demonstrations, showing that direct current cannot be transformed

control points and electricity supplies had been noted. Some of the halls were never intended for such a function; and so we were sometimes faced with inadequate power supplies and lighting, usually controlled from widely separated points. This was the reason for the additional lighting equipment, telephones, and signal lights mentioned above.

Preparing the Stage

The equipment was moved into the hall early on the morning of the lecture, and the final stage layout was settled by lunch-time. This required much careful checking of sight lines. In only a few cases was the stage positioned so that everyone in the hall could see everything, and therefore the best compromise had to be chosen. Demonstrations were wired and tested during the afternoon, and sound, lighting and communication systems were installed. The sound system used comprised a microphone and radio transmitter carried by the lecturer, the signal from which was picked up by a receiver in the hall and fed into the normal amplifying system. This method worked exceedingly well, as it gave me complete freedom of movement, but had the disadvantage with the particular equipment used that I could not switch off, so that if anything went wrong I could not talk privately to my assistants. There was some anxiety at one hall as to whether messages passing between the garage next door and its taxis would be picked up, but fortunately the screening proved adequate.

By tea-time, all work was completed except for a last-minute check of all equipment just before the doors were opened. The lecture passed all too quickly and in all cases without serious mishap, although we had our fair share of unscheduled incidents. It may be thought that the work of delivering the lecture would become somewhat tedious after the first one or two presentations; but this was not my experience, because the sequence of script, demonstrations, unscripted commentary and films was so complex that no two lectures were exactly alike. After the lecture, and a quick tidying of the equipment, a very welcome meal was provided by the Local Centre. Next morning the equipment was dismantled and reloaded for return to base or to the next hall.

Such was the work involved in the presentation of a typical lecture. At some Centres an additional afternoon lecture was given to local schools, in which case as much preparation as possible was made during the previous evening.

Attendances

The lecture was first delivered in Newcastle upon Tyne in November and was given in Sheffield, Birmingham, Rugby, Cardiff, Southampton, London, Stoke on Trent, Nottingham, Manchester, and Liverpool before its final presentation in Glasgow in March. The total attendance was 25 893, consisting of 5221 members and 20 672 visitors, of whom 5480 were schoolchildren who attended the special schools lectures in Birmingham, Southampton, Nottingham, Liverpool, and Glasgow. The total distance travelled by the lecture team, mostly by rail, was approximately 2500 miles, roughly the distance from London to Baghdad.

On such a tour, many interesting or amusing incidents are bound to occur, and our experiences were no exception. For instance, there was our extraordinary luck with the weather, all the heavy snowfalls of the winter occurring in between lectures, with the exception of Cardiff, where it was so cold that the team worked in overcoats and gloves throughout the day. On this occasion I greatly envied my assistants, because they were able to continue wearing their overcoats under their overalls during the lecture, whereas I had to stand and shiver.

There was the old gentleman with the deaf aid who appeared at two lectures and wandered about the front of the hall aiming his microphone at me in the vain hope of improving reception. If only he had asked us beforehand we could have equipped him with headphones supplied from our microphone receiver.

Authoritative Comment

The radio microphone caused a great deal of interest, and we overheard one member of the audience explain the absence of a microphone cable by stating authoritatively that the lecturer was miming to a recording.

When visiting Glasgow, after giving the lecture there, I was standing on Craigendoran Station when I overheard two passengers discussing a poster giving warning of delays due to electrification work in progress on the line. In reply to his companion's question regarding the system to be adopted, the other remarked that he had recently been to a lecture in Glasgow where he had discovered that alternating current would be used with overhead supply. He then went on to give a very good précis of the lecture. We know, therefore, that at least one of our listeners learned something from our efforts!

In concluding this account of some of our impressions I would like to thank all the many people who assisted directly and indirectly in the presentation of the 1957–58 Faraday Lecture. Their efforts contributed greatly to ensuring its success and to making the tour the interesting and enjoyable experience it proved to be.

A Review of the Proceedings, Parts A and B

SHORT REVIEWS OF PAPERS

On the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

Bridge Measurement of Symmetrical Components

A short review of a Measurement and Control Section paper (No. 2703) entitled 'Bridge Methods for Determining Symmetrical Components of Current, Voltage and Power, with Special Reference to Electrical Machinery' and a Utilization Section paper (No. 2704) entitled 'Symmetrical-Component Analysis Applied to Phase Convertors of the Ferraris–Arno Type', by J. E. Brown, B.Sc., Ph.D., and R. L. Russell, M.Sc., Associate Members. The papers are published this month in Part A of the Proceedings. The authors are in the Electrical Engineering Department, University of Bristol.

SYMMETRICAL-COMPONENT METHODS WERE SO REMARKABLY well adapted for the particular purpose for which they were originally devised—the solution of power-distribution problems—that they have barely recovered from their initial success. That they could be used for general circuit analysis was relatively slow to be recognized, and their application to machines is a much more recent development.

In most machine problems the analysis is complicated, and to produce numerical results by established methods is frequently discouragingly laborious, though the use of computers has been proposed. Much of the difficulty arises from adopting a theoretical structure which recognizes the independent physical existence of sequence-component quantities, on the one hand, while not pressing the consequences of so doing to their logical conclusion, on the other. A considerable measure of simplification is introduced in machine analysis by expressing the so-called inspection equations in terms of sequence-component quantities and by measuring these directly instead of the phase or line values as is more usually done. In this way theory and practice can be compared much more easily and at an earlier stage in the calculation than would otherwise be the case. Presumably because there has been little reason hitherto to do otherwise, the measurement of sequence components is often treated as a theoretical topic in analytical terms. 'While there is in actual service quite a number of special designs of relays responding to the different components of currents, voltages and powers, corresponding designs for measuring instruments are not very frequent.' This statement, towards the end of a book on symmetrical components,* is only a little less true now than when it was written, though there are many isolated references to measurement scattered throughout the literature, many of them in foreign journals.

Sequence-component quantities can, in fact, be determined with the ease and reliability of ordinary routine measurement. The circuits finally chosen from many which have been suggested are simple and, properly designed, can be used with instrument transformers. They have the useful property that the required adjustments, which are easy to make, are not dependent on the impedance of the meters employed. The bridges could therefore be produced commercially as simple pre-adjusted assemblies of resistors and capacitors or inductors, to be employed with the users' instruments and instrument transformers in the usual way. The circuits are, of course, frequency-sensitive, but the error can be arranged to be linear, and a correction is easily applied if required. Errors arising from variations in mains frequency are normally negligible. Both 3-phase and 2-phase (90°) bridges can be used.

The current and voltage circuits are duals of one another so that, correctly interpreted, the properties of one can be inferred from the performance of the other. This is thought to be a desirable feature and is clearly brought out in the analysis, when expressions for dissipated power, input impedance, etc., can be shown to be reciprocally related.

These measuring techniques have obvious applications in transmission systems and for purely instructional purposes, but they were primarily developed for investigating general problems of the asymmetrical operation of rotating polyphase machines. A particular example is the Ferraris–Arno phase convertor. In view of the proposed developments in a.c. traction installations and the increased demands which there will be for auxiliary drives for railway rolling-stock, problems of phase

* NEUMANN, R.: 'Symmetrical Component Analysis of Asymmetrical Polyphase Systems' (Pitman, 1939), p. 194

conversion and related topics are likely to assume major importance.

The explanation of the general *n*-machine capacitor Ferraris–Arno system, as developed by a systematic application of symmetrical-component principles, is singularly simple and direct, and the function of the pilot motor in the phase-conversion process is clearly illustrated. Moreover, in the form set out, it is particularly easy to take corresponding measurements using the bridges and thus to verify the theory directly. It is not necessary to ignore the effects of saturation, for measurements are made under running conditions and non-linearities are therefore taken into account as they occur. Optimum conditions can be achieved by using a phase-balancing capacitor whose value can be determined by a simple geometrical construction based on coaxal circles or by an equally simple practical test. The arguments are applicable to both 2-phase (90°) and 3-phase systems, and in some respects the former is to be preferred.

The general solution includes, as particular cases, a number of features of special theoretical interest or practical importance. One of these is the single-phase operation of the 3-phase motor as a split-phase capacitor motor, which is not always satisfactorily explained or usually discussed in terms of phase conversion. The ease with which the balancing capacitor for optimum conditions can be found both practically and geometrically is in marked contrast to the tedious iterative operations which have been proposed.

A number of performance curves show that in all cases there is a good agreement between theory and practice.

621.317.733 : 621.313.1.012.8 : 621.313.333

Short-Circuit Testing of Electrical Equipment

A short review of a Graduate and Student Section paper with the above title, by G. E. Moreton, B.Sc.(Eng.), Graduate. The paper was read before the North Staffordshire Graduate and Student Section on the 23rd October 1957 and was awarded a Graduate and Student Premium by the Council. The author is with the English Electric Co. Ltd.

AS EARLY CIRCUIT-BREAKERS WERE MECHANICALLY AND electrically weak, it was soon found necessary to institute full-scale short-circuit testing, and the first testing station in Great Britain was built in 1929. Other stations were built shortly after, and just before the recent war the need was recognized for a co-ordinating authority to standardize test procedure. Thus the Association of Short-Circuit Testing Authorities (A.S.T.A.) was formed.

To maintain a high standard of testing, each station carries on its staff an observer directly responsible to both the National Physical Laboratory and the Association for the accuracy of the results obtained.

A Typical Testing Station

One typical testing station consists of two similar installations capable of independent or parallel operation. When operating in parallel the plants have an instantaneous short-circuit output in excess of 2500 MVA. Each installation is equipped with a 3-phase alternator driven by an induction motor and an associated super-exciter separately driven by a second induction motor. The alternator output is taken to a master circuit-breaker and thence to banks of reactors and resistors. It is then fed to a 'make' switch, through step-up or step-down transformers if required, and on to the terminals of the apparatus to be tested.

The voltage applied to the apparatus on test is controlled by the excitation of the machine and the transformer ratio, while the output current is controlled mainly by the reactance in the circuit. The power factor is determined by the resistance used.

Complete control of the plant can be obtained from either of the two control rooms, the sequence of operations being determined by the setting of a 20-channel timing cam which can be made to actuate such equipment as the make switch, test circuit-breaker, master circuit-breaker and recording oscillographs. These latter are of the cathode-ray and electromagnetic types for recording high- and low-frequency phenomena respectively.

Test Procedure

To carry out a series of tests, the engineer-in-charge must know the basic details of the apparatus on test, such as MVA rating and operating voltage, and details of the operating mechanism if a circuit-breaker is concerned. He is also given the standards with which the tests must comply and can thus calculate the current required during each sequence. From the known plant constants, the reactance and the resistance, together with the excitation necessary to give the required output from the alternator, can be determined. A programme giving details of the test plant is prepared, to enable the station staff to set the circuit configuration and constants. Information about the measurement circuits is used in calibrating the recording apparatus.

The timing cam is set, and when the alternator has been excited to the required value, by control of the field of the pilot exciter, a firing button causes the cam to revolve and thus operate the plant switchgear, recording equipment and apparatus under test.

It is usual after each alteration of the main circuit connections to perform a low-voltage timing test which checks that all the equipment is functioning correctly.

Switchgear Testing

Each type of circuit-breaker necessitates a different testing procedure, for which rules are laid down by A.S.T.A. in conjunction with the British Standards Institution. For normal oil circuit-breakers the tests may be divided into six parts.

The performance must be proved over the whole range

of short-circuits which the breakers may be called upon to interrupt, and low-current tests are often as damaging as the full-value tests. An oil circuit-breaker fitted with an arc-control device must be so designed that it will interrupt its maximum rated short-circuit current. Since the arc-extinguishing process is dependent on the amount of gas produced, which is proportional to the current broken, it follows that the efficiency of the device will be much lower at low currents.

Air-blast circuit-breakers are also subjected to severe stress at low currents, but for a different reason. Since the arc-extinguishing medium is air moving at high speed, the process is independent of the current broken. Thus at low currents the medium is more than sufficient to prevent re-establishment of the arc after a natural current zero, and in fact it extinguishes it while a finite current is still flowing. This gives rise to very high induced voltages.

The breaker must also be able to make on to a fault up to its rated short-circuit value, and tests include make–break checks to ensure that it is able to make on burnt contacts.

Thus the first five parts of the series consist of three breaking tests at 3 min intervals at 10%, 30% and 60% of rated short-circuit current, together with three asymmetrical and three symmetrical tests at full value, the latter including make–break tests. The sixth part is a full-value test applied to the closed breaker for a period of one or three seconds in order to prove that it will be able, if required, to carry the fault until cleared by another breaker.

These six duties, if successfully carried out, are sufficient to warrant the issue of a Certificate of Rating, which contains documents under seal to identify the breaker tested, its record of performance during test and its condition after test, together with oscillograms and photographs of the circuit-breaking parts. It is signed by the chief of the testing station and the A.S.T.A. observer and submitted to the Association for approval and registration before signature by a member of the Council of the Association.

Fusegear Testing

The testing of fuse-gear is slightly different, in that the speed of operation is so great that the current has insufficient time to reach its full value before the circuit is broken. Thus it is necessary to determine the prospective current by replacing the fuse by a link of negligible impedance and measuring the current flowing. Also, when a fuse is tested, the recovery voltage must be maintained for at least 30 sec to prove that it will withstand application of its rated voltage indefinitely.

Other Equipment

Tests are not normally carried out on transformers, current-limiting reactors, resistors, and current and voltage transformers, except at the request of customers. However, tests on such equipment are laid down in various A.S.T.A. publications which call for a very high standard of performance, and everything is done to ensure that any apparatus certified meets or surpasses these high standards. 621.317.2.014.3

Protection of Turbo-Alternators

A short review of a Graduate and Student Section paper entitled 'Modern Techniques in the Protection of Large Turbo-Alternators', by C. F. Ferguson, B.Sc.(Eng.), Graduate. The paper was read before the North Staffordshire Graduate and Student Section on the 10th April 1957, and it was awarded a Graduate and Student Premium by the Council. The author was formerly with the English Electric Co. Ltd. and is now with the North of Scotland Hydro-Electric Board.

THE SIZE AND IMPORTANCE OF INDIVIDUAL GENERATING units in present use accentuate the need for adequate and reliable protective gear on such machines. Rapid detection and isolation of faults to ensure minimum damage and thereby shorten the period of outage require special attention. Furthermore, extreme care must be taken to ensure that no machine is disconnected from the busbars during transient or sustained fault conditions on the power system not involving danger to the machine.

The protection and tripping arrangements for the alternator and the turbine in steam-driven units of 60 MW and over require particular consideration, since the unit auxiliaries are supplied directly from the generator via only a step-down transformer.

Differential Protection

The main item of alternator-stator protection is provided by a longitudinal differential scheme, and the simplest and most satisfactory method of applying it is to use a circulating-current system with relays biased to be inoperative for faults external to the machine. This allows low current settings to be used, and therefore fast operation to be obtained, for an internal fault.

Stator Earth-Faults

The differential system protects against phase-to-phase faults, and, provided that sufficient fault current flows, also protects against phase-to-earth faults. However, owing to the need to limit damage to a machine on fault, a high-impedance earthing device is normally used, and separate earth-fault protection is applied.

Three methods of earthing the machine neutral are in common use: resistance; voltage transformer and surge diverter; and distribution transformer and resistance. Limitations of fault damage, surge impedance and physical size are main considerations affecting the choice of method. Earth-fault protection is obtained by measuring the current in the device, or voltage across it, under fault conditions; a similar degree of protection

is afforded to the machine with each method of earthing.

Over-Current

Over-current protection is primarily applied as back-up to the generator and generator-transformer differential protection. In some cases the relay is required to operate also for a sustained external fault; the protection must then discriminate with the power-system protection. Owing to this requirement, and to the necessity of taking the fault-current decrement of the alternator into consideration, difficulty is sometimes experienced in obtaining suitable fault settings for external fault conditions. However, since most large generators are connected to high-voltage busbars on which separate busbar protection is provided, the use of over-current protection for external faults is generally unnecessary, and the over-current relay is required to operate only for internal faults. In this case, since the fault current which can be fed into the machine from the busbars is relatively high, and often has no pronounced a.c. decrement, a suitable setting for the relay can easily be obtained.

Negative-Phase-Sequence Protection

The rotors of modern high-output generators are of the solid type and therefore particularly prone to local overheating under conditions of unbalanced loading on the machine. System faults causing unbalanced loading would normally be cleared by the system protection before the generators were endangered. Since, however, sustained unbalanced loading may lead to mechanical failure of the rotor, it is essential to guard against maloperation of the system protection. The protection scheme, which requires careful design, takes the form of a negative-phase-sequence network fed from three delta-connected current transformers. An induction relay matched to the thermal characteristic of the machine is connected to the output from the network.

Field Failure

Failure of the alternator field does not immediately create an emergency condition as far as the machine is concerned, and present-day practice is normally to arrange the protection to give an alarm only. Stator overheating becomes critical if the field cannot be restored promptly, in which case the load should be reduced swiftly. Sustained loss of field for more than 5–10 min necessitates taking the machine off the busbars.

Alternator-excitation circuits are not normally earthed, and an earth fault is therefore not by itself a serious condition, provided that warning is given of its existence. On receiving an earth-fault alarm, the operating staff must, of course, make arrangements to take the set out of service as quickly as possible. Other abnormal conditions affecting the alternator which can occur, such as overheated bearings and cooling-system faults, are covered by alarm devices, and remedial action is left to the operating staff. The shut-down of the set may become necessary under these conditions, but its urgency is not generally considered sufficient to warrant automatic shut-down.

The chief dangers to which modern high-pressure steam turbines may be subjected, and which require the use of automatic protective gear, are overspeed, loss of vacuum and reduction in boiler pressure.

Overspeed

When a large turbo-alternator is operating at or near full load and the load is suddenly lost, owing, for example, to a heavy system fault, it is possible for a considerable overspeed to be attained, since the steam pressure and rate of steam flow at the turbine valves are initially unchanged. If the control of the steam valves is left entirely to the centrifugal governor, the valves will not close immediately, since the governor will not operate until the speed has risen. A further time-delay inherent in the governor system will occur before the valves are fully closed, and even then the energy of the steam entrained in the turbine casing will cause a further rise in speed. The total overspeed on loss of load will be the sum of the increases due to these conditions.

While an emergency overspeed trip is always provided, which closes the emergency stop-valves on an overspeed of $10\% \pm 1\%$, it is obviously desirable to avoid a complete shut-down if at all possible. In these circumstances it is necessary to incorporate in the governing system some device which will speed up the closing of the turbine throttle valves, and which will restore the control of the set to the governor once the initial speed rise has been contained. This may be achieved by a device sensitive to steam pressure and high load on the machine. When a combination of high steam pressure in the turbine and low load on the set occurs, the device quickly adjusts the oil pressure in the throttle-valve oil servo cylinders, and the throttle valves close rapidly. By this means the rise in speed resulting from loss of load is held below that at which the overspeed trip would operate.

Loss of Vacuum

Loss of vacuum, caused by failure of the auxiliaries or the individual pumps, results in overheating of the turbine low-pressure cylinder casing and blading. The load on the set must then be reduced to avoid dangerous temperatures, and should it not be possible to restore the vacuum quickly, or at least check the loss, it becomes necessary to shut down the set. An electrical device sensitive to condenser vacuum progressively closes the throttle valves through the governor speed gear, thereby removing load from the machine in proportion to the rise in pressure. Should the loss of vacuum remain unchecked, this process continues until all load has been removed from the machine, and further loss causes automatic shut-down of the set. Should it be possible to check the loss at any stage before this happens, no

further reduction in load takes place. When normal vacuum has been restored, the device remains inactive, and load is restored by normal operation of the load-control switch in the control room.

Reduction in Boiler Pressure

Should a reduction in boiler pressure occur through failure of one or more boiler auxiliaries, it is necessary, with present-day large high-pressure boilers, to remove load from the turbine in order to prevent the quality of the steam supplied to the turbine becoming unsuitable. Under these conditions a device operated by steam pressure operates in conjunction with the vacuum 'de-loading' gear. A similar sequence of operations ensues as with loss of vacuum, except that no automatic shut-down occurs if the fall in pressure cannot be checked, and appropriate action is left to the operating staff.

Conclusion

In addition to the above automatic protective devices, the importance and complexity of modern turbo-alternators make necessary a considerable number of supervisory and alarm devices, which are of no less importance for the satisfactory operation of a complete generating unit. Prompt response to abnormal conditions indicated by such devices is the duty of the operating staff, and efficiency and reliability in the automatic protective gear must therefore be balanced by these same qualities in the generating-station personnel.

621.316.91 : 621.313.322-81

Testing of High-Voltage Power Transformers

A short review of a Graduate and Student Section paper with the above title by R. E. James, B.Sc.(Eng.), Graduate. The paper was read before the Rugby Graduate and Student Section on the 6th March 1957, and it was awarded a Graduate and Student Premium by the Council. The author is with the British Thomson-Houston Co. Ltd.

THE TESTING OF TRANSFORMERS, AS OF OTHER MANUfactured equipment, is essential both to confirm the predicted performance and to ensure that the materials and workmanship are of the required standard. Many tests are applied during manufacture and on completion of the unit. Some are developmental in nature, although many are routine in order to guarantee that the finished product will meet the specification (e.g. B.S. 171).

Operating Characteristics

The tests necessary to confirm the transformer operating characteristics include measurement of the ratios and resistances of the windings and the various reactances and the losses on short-circuit and open-circuit. Accurate estimation of stray-load loss is still not possible, although existing methods suffice to ensure meeting the limits quoted in the specifications.

Steady-State Performance

As a transformer should operate for 25 years or more, tests must be made to demonstrate that, on full load, the temperatures of the insulations—primarily cellulose materials and oil—do not exceed a safe value. Thermal tests can be carried out in three ways:

(1) A conventional short-circuit test, in which the windings are over-rated in order to dissipate the *total* losses as I^2R losses. Shunt capacitors may be used for power-factor correction if necessary

(2) A d.c. heat run, where power-factor correction is impracticable

(3) A 'back-to-back' test at full voltage, requiring two units.

The first method is probably the commonest (see B.S. 171), but, owing to various circumstances, serious consideration may have to be given to the others mentioned—especially with the possible increase in ratings to over 200 MVA. Also, it is probable that short-circuit heat runs are pessimistic for layer-type windings, as it has been shown* experimentally that heat transfer is enhanced if oil is stressed electrically.

Steady-state high-voltage tests are devised to check the electric strength of the major insulation to earth and between windings, and the insulation between turns, sections and layers.

There are several advantages in using high-voltage dividers. The justification for the high test levels chosen for transformers appears to be that units passing the tests have not failed in service, there apparently being little scientific basis for the choice. These high test voltages are probably essential, while the criterion of failure during test is simply that no major breakdown occurs. It seems clear that more sensitive methods of detecting failures should be investigated. For example, the conditions within the insulation during the test could be studied by the detection of discharges using some form of ionization equipment. It is appreciated that there are difficulties regarding spurious discharges and the interpretation of results, especially as the transformer may operate for its anticipated life with small discharges present. Nevertheless, it is clearly essential that work on this subject of discharge detection should be pursued to obtain experimental experience and to gain information for the designer.

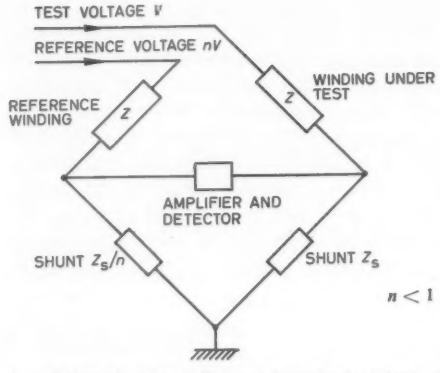
The electric strength of the insulations employed in transformers depends greatly on the reduction of their moisture content. The removal of moisture is achieved by a vacuum dry-out process, and during this operation assessment must be made of the insulation condition. Three methods of measurement are employed: power factor, change in insulation resistance with time, and the more recent technique of measuring capacitance change (or dispersion) with frequency or time. Each method has its merits, and the best compromise is that a manufacturer should use all techniques until sufficient experience has been gained to decide the most reliable.

* ALLEN, P. H. G.: *BTH Co. Summer School Proceedings*, 1956, p. 47

Transient Performance

In addition to its steady-state function, a power transformer is usually designed to withstand various transient conditions, including the effects of lightning and switching surges, sudden short-circuits and magnetizing surge currents. Recent studies have been made in America regarding switching-surge tests on transformers.

Impulse testing is a very specialized technique, requiring considerable experience in the interpretation of records obtained by electronic and photographic methods taken in the presence of very high voltages (1500 kV or more) of short duration (50 microsec or less). The difficulties are especially prevalent in the testing of transformers, where the test object has inductance and resistance as well as capacitance, which, under certain conditions, may result in dangerous oscillations within the windings. The major problem with transformers is the method of fault detection to be adopted, especially as the sensitivity depends on the particular design. Advances in fault detection methods include the use of two time-sweeps, e.g. 15 microsec and 250 microsec, on the cathode-ray oscilloscope, the use of the recurrent-surge oscillograph for preliminary investigations at low voltage, and a comparison method of detection known as the 'differential' method—a form of which has been developed and used for the past seven years.* In this technique the current or voltage in the winding under test is compared with that at a lower level in a winding of similar characteristics, both windings receiving a surge of identical shape. The comparison is made electrically, allowing for the voltage discrepancy, and the difference is amplified. Thus, in principle, the technique is a bridge method and therefore inherently more sensitive than such methods as observation of the line voltage, neutral current and transferred current or voltage. The comparison method is especially useful where non-linear resistors are connected across tappings.



1 *Principle of a differential method of fault detection*

Other developments in impulse testing include controlling the time of chop by a triggered gap and the differential method for ionization detection.

Conclusions

It is clear that, to obtain the information required to improve transformer designs, consideration should be given in some instances to the possibility of introducing new, or modifying existing, testing techniques.

621.317.3 : 621.314.2

* WADLAND, D.: 'On Precision Electrical Instruments', *Proceedings of Symposium*, National Physical Laboratory, November 1954. Discussion on session 5, p. 1

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available shortly.

Non-Linearity in Cracked-Carbon Resistors

A synopsis of a Measurement and Control Section paper (No. 2747) entitled 'Measurement of Non-Linearity in Cracked-Carbon Resistors', by G. H. Millard, B.Sc., A.Inst.P. The paper will be published in Part B of the Proceedings. The author is with the British Broadcasting Corporation.

THE NON-LINEARITY OF A NUMBER OF SMALL CRACKED-carbon resistors has been investigated at both audio and radio frequencies. In the case of one resistor, non-linearity coefficients of order higher than the third were measured; their effect is considered for various levels of the input signals. The degree of non-linearity is negligible for most purposes.

621.315.56 : 621.316.86

Waveform Generator for Testing T.V. Links

A synopsis of a Radio and Telecommunication Section paper (No. 2687) entitled 'A Pulse-and-Bar Waveform Generator for Testing Television Links', by I. F. Macdiarmid, Associate Member, and B. Phillips, B.Sc.(Eng.). The paper was published last month in Part B of the Proceedings. The authors are at the Post Office Research Station.

AMONG THE TEST SIGNALS USED FOR MEASURING THE transmission performance of television links are 'sine-squared' and 'smoothed-bar' pulses. The paper gives details of the design of a test-signal generator which, at the line-frequency repetition rate, produces a composite waveform consisting of a sine-squared pulse, a smoothed-bar pulse and a normal line-synchronizing pulse. The

sine-squared pulse may have a half-amplitude duration of either T or $2T$, as selected by a switch, where $1/2T$ is the nominal upper frequency of interest in the television system (e.g. 3 Mc/s in the British 405-line system). The bar pulse is about half as long as the line period and has transitions of 'integrated sine-squared' shape.

To facilitate precise measurements the generator has been designed with particular emphasis on stability of waveform shape and freedom from jitter.

Consideration is also given to analogous test signals for colour-television systems. 621.373.44 : 621.397.6

Generalized Locus Diagram for Induction Motors

A synopsis of a Utilization Section paper (No. 2696) with the above title, by P. Lomb, Dipl.Ing., and G. Ellesworth, B.Sc.(Eng.), Associate Member. The paper is published this month in Part A of the Proceedings. Mr. Lomb is with Australian Electrical Industries Pty. Ltd., New South Wales, and Mr. Ellesworth is in the Department of Electrical Engineering, University of Adelaide.

IT IS WELL KNOWN THAT THE CONSTRUCTION OF THE induction-motor circle diagram presupposes the motor characteristic resistances and reactances to be constant. The paper discusses the variation of these circuit parameters and its influence on the current locus. It also provides a physical picture of conditions at starting and a simple technique for the construction of new 'output' and 'torque' lines, from which the machine performance may be computed over the whole speed range. The reliability of the method is indicated by comparison with experimental data. 621.313.333

Reactor/Capacitor Combination for Speed Control of Induction Motors

A synopsis of a Utilization Section paper (No. 2697) entitled 'Application of a Variable-Reactor/Capacitor Combination for Reversing and Controlling the Speed of Polyphase Induction Motors', by Prof. T. V. Sreenivasan, B.E., M.Sc.Tech. The paper is published this month in Part A of the Proceedings. The author is an Assistant Professor at the Indian Institute of Technology, Kharagpur.

BY INTRODUCING A VARIABLE REACTOR PARALLELED WITH a fixed capacitor in one of the supply lines of a 3-phase induction motor, the speed and direction of rotation can be controlled, by controlling the value of the external effective reactance. Applying the method of symmetrical components, both the starting and running performances of such a motor are analysed. If the external reactance is made to vary automatically with speed, this gives a method of controlling, and reversing with dynamic braking, the speed of the motor. 621.316.718 : 621.313.333

Reduction of Low-Frequency Noise in Feedback Integrators

A synopsis of a Measurement and Control Section paper (No. 2705) with the above title, by E. M. Dunstan, M.Sc., and J. Somerville, B.Sc., Graduate. The paper will be published in Part B of the Proceedings. The authors are in the Department of Electrical Engineering, University of Manchester.

TWO METHODS OF DESIGNING A FEEDBACK INTEGRATOR for use with repetitive inputs are described. Each gives considerable improvement in signal/noise ratio compared with a conventional direct-coupled integrator.

The first uses an error amplifier with a single CR coupling. In the second, phase correction is applied to the output from a low-accuracy direct-coupled integrator, increasing the accuracy but retaining the high signal/noise ratio of the low-accuracy integrator.

621.375.13 : 621.372.57

Gas-Discharge Noise at Centimetre Wavelengths

A synopsis of a Radio and Telecommunication Section paper (No. 2711) entitled 'Measurements on Gas-Discharge Noise Sources at Centimetre Wavelengths', by A. C. Gordon-Smith and J. A. Lane, M.Sc., Associate Member. The paper will be published in Part B of the Proceedings. The authors are at the Radio Research Station.

MEASUREMENTS ARE DESCRIBED IN WHICH THE EFFECTIVE noise temperature of the type-CV1881 argon-discharge tube is determined by comparison with both a thermal noise source and a continuous-wave signal, at a wavelength of 3·2 cm (frequency, 9·4 Gc/s). The results obtained were $10\,590° \pm 500°$ K and $11\,050° \pm 1350°$ K, respectively. The results are compared with data previously given for argon noise sources. 621.317.34 : 621.387

Amplitude-Modulated Transmitter Class-C Output Stage

A synopsis of a Radio and Telecommunication Section paper (No. 2724) with the above title, by C. Mayo, M.A., B.Sc., and H. Page, M.Sc., Members. The paper will be published in Part B of the Proceedings. The authors are with the British Broadcasting Corporation.

THE MODE OF OPERATION OF THE AMPLITUDE-MODULATED transmitter Class-C output stage is discussed, with particular reference to the case where the load impedance varies over the working frequency band; a typical example is that of a long-wave broadcasting transmitter. The impedance presented to the anode must be symmetrical with respect to the carrier frequency if non-linear distortion of the signal is to be avoided.

621.375.2 : 621.396.61

OBITUARY

RICHARD AMBERTON

Major Richard Amberton, who was born on the 7th September 1884, died on the 28th May 1958. He was educated at the City of London School and attended Finsbury Technical College part-time. He joined the Sturtevant Engineering Co. in 1904 as a draughtsman, dealing with electric-motor starters, new designs of which were being prepared in anticipation of Joseph Chamberlain's tariff-reform proposals, and to replace imported American apparatus.

After three years he went to the General Electric Co., Schenectady, for experience, where he came into contact with Mr. Schattner. From this association the Electrical Apparatus Co., now of St. Albans, was formed in 1907, and Amberton became sales director.

During the 1914–18 War he served in the Royal Engineers and on being wounded left the Army to become director of various sections of the department of engineering at the Ministry of Munitions for two years.

On his return to civilian life he became in 1920 a director of Bray Markham and Reiss Ltd., London, and chairman of the Unbreakable Pulley and Millgearing Co. Ltd., Manchester, and of the Cooper Roller Bearings Co. Ltd., King's Lynn, in 1924.

He left the Electrical Apparatus Co. to form the firm of Amberton and Partners, where he became concerned in a number of projects and agencies of electrical interest, particularly in relation to phenol-resin insulation. His firm became agents for Dorman and Smith Ltd. in 1935, of which company he joined the board in 1936. In 1948 he became a director of Dorman Smith Holdings Ltd., on the formation of that company. He ceased to be a director in 1956, at the age of 73.

Amberton's favourite hobby, as a younger man, was punting, in which he was highly proficient, and he entered into the Thames punting competitions with success. Later on in life, golf became a hobby; and he and his wife were keen bridge players. He was always extremely well dressed and 'booted', with clothes for every occasion. He sported a monocle—but in no way with affectation—and he was unusually tall and elegant.

He is survived by his widow and two sons.

He joined The Institution as a Student in 1902 and was elected an Associate Member in 1911 and a Member in 1925.

THOMAS CHARLES GILBERT

Thomas Charles Gilbert, who died on the 28th June 1958, was born on the 8th February 1888 at Folkestone. He received his schooling at Harvey Grammar School, Folkestone, and served an apprenticeship with T. W. Southee.

His pre-war enlistment in the Territorial Army led to service in the Cinque Ports (Fortress) R.E. throughout the 1914–18 War; and during the Second World War he again served with the Royal Engineers, this time with the rank of captain.

In 1919 he founded the firm of electrical contractors, T. C. Gilbert and Co. Ltd., Folkestone, which ceased business in 1940 following the effective evacuation of the district in the previous year.

The increasing use of portable appliances, becoming in time universally fed from a.c. mains, with a greater risk of fatal shock, caused Gilbert in the very early days of the growth to doubt the efficacy of solid earthing; and he was the pioneer of the 'earth or insulate' controversy. Aware that insulation could only provide partial protection, he turned to a study of Continental wiring systems and as a result became dedicated to the voltage-operated leakage trip, which he caused to be introduced to this country in 1930.

He wrote *Artificial Earthing for Electrical Installations* (Ernest Benn) in 1932 and contributed widely to the electrical Press over many years. Later he turned his attention to non-metallic conduit systems, and in 1944 patented such a system, later becoming managing director of Flexible Non-Metallic Conduits Ltd. In 1951 the firm of Gilflex Conduits Ltd. was incorporated, of which he was chairman and managing director at the time of his death.

Many electricians engaged in installation work who were his apprentices can look back to the soundness of their training. He is survived by his widow and two sons.

Gilbert joined The Institution as an Associate Member in 1930 and was elected a Member in 1948. His paper on *Voltage-Operated Earth-Leakage Protection* was published in the *Journal* in 1941. He had been a member of the Council of the Electrical Contractors Association and had served for some years on the Advisory Committee of the City and Guilds of London Institute. P. A. B.

ERNEST ARTHUR GATEHOUSE

Ernest Arthur Gatehouse, who was born on the 13th June 1883, died on the 14th June 1958 at his home at Horley, Surrey. A son of Tom E. Gatehouse, also a Member of The Institution, he was educated at Alleyn's College of God's Gift, Dulwich, and at the Central Technical College, South Kensington, and was then a pupil with Dick, Kerr and Co., Preston. In 1906 he became an erecting engineer with the company. In 1913 he transferred to the British Thomson-Houston Co., Rugby, as commercial engineer and was later appointed assistant manager of the Contract Department.

In 1923 he joined the staff of *Electrical Review* as joint manager and director, a position he held until 1931.

Gatehouse was a member of the original syndicate which investigated the possibilities of manufacturing self-contained petrol-operated rock drills and road breakers, incorporating entirely new principles. He became one of the founding directors of Warsop Power Tools Ltd., which was formed in 1933 for the development of these tools. He was for many years technical director and deputy chairman of the company, and until his recent illness he retained an active interest in its personnel and affairs.

He joined The Institution as an Associate Member in 1913 and was elected a Member in 1923. J. H. C./E. W.

JOHN HERMAN GYLES

John Herman Gyles, who died on the 5th December 1957 at Pinetown, Natal, was born at Hayle, Cornwall, in 1879. He received his education at Hayle and also in Cardiff, and in 1895 commenced an apprenticeship with Walker and Co., Cardiff, at the same time attending the University of South Wales. On completion of his apprenticeship he joined the Marquard Accumulator Co. but for health reasons later resigned and went to sea, during which period he visited South Africa. Gyles came from a sea-going family, his father having served as an engineer with the Haynes Shipping Co., operating from Hayle.

In 1900, following his visit to Durban, he left the sea and joined the Natal Government Railways at Durban and later in the same year accepted a post with the Durban Municipal Electricity Department. In 1907 he became electrical superintendent at the Durban municipal power station, in which position he served until 1928, when he was promoted to chief distribution engineer in the same department. In 1932 he served as assistant borough electrical engineer, Durban, and from 1933 to 1939 as borough electrical engineer.

Following his retirement in 1939, which coincided with the outbreak of war, he joined the Technical Services of the Union Defence Force in Pretoria and served with the rank of major until 1943, when he was appointed by the Union Government to the position of controller of electrical material in Durban in the building-control organization which had been formed under the emergency war regulations. He held this position until 1947, when this control was withdrawn.

He met his wife in Durban, and they were married in 1912; it is of interest that Mrs. Gyles's father was also connected with the sea, having served for many years as captain of one of the Haynes Shipping Company's vessels. Gyles's only sister is still living in Budleigh Salterton, Devon.

He was a keen golfer and very fond of reading. He is survived by his wife and daughter.

He joined The Institution as an Associate Member in 1912 and was elected a Member in 1935. He served as president of the Association of Municipal Electricity Undertakings of Southern Africa for the year 1937–38. R. M. O. S.

PERCY GORDON HIEATT

Percy Gordon Hieatt died suddenly on the 25th June 1958, while on holiday visiting relatives and friends in Northamptonshire, where he was born on the 2nd December 1884. He received his early education at St. Mark's College, Chelsea, and St. Francis Xavier's College, Bruges, and his technical training at Regent Street Polytechnic.

After a year with the Gilbert Arc Lamp Co., he joined the North Metropolitan Electric Power Supply Co. in 1903, to begin a lifetime of service in the electricity supply industry. From 1912 to 1918 he was at York power station, and after short periods at Rotherham and Derby he moved to Croydon in 1920 and to Hackney in 1927.

In 1931 he became control engineer with the Central Electricity Board, Mid-East England, becoming chief control engineer a year later and subsequently senior assistant operations engineer. In 1946 he was appointed operations engineer for the Mid-East and North-East England Areas; and when the industry was nationalized in 1948 he became system operations engineer with the Yorkshire Division of the British Electricity Authority. Shortly afterwards he became personal assistant to the divisional controller, a post he held until his retirement in 1954.

'P. G.', as he was generally known, was a man who served quietly and faithfully but with intense tenacity and patience. The latter quality was particularly marked after two major operations he endured ten years ago. He devoted practically all his spare time to reading and to his home life. He is survived by his second wife, whom he married in 1957, and by his daughter.

He joined The Institution as an Associate Member in 1933 and was elected a Member in 1947. He served on the North Midland Centre Committee from 1937 to 1940. He was also a Member of the Institute of Fuel. W. J. A. P.

HENRY GEORGE HUGHES

Henry George Hughes, M.SC., who died in June 1958, was born on the 13th October 1890. He received his scientific training under Prof. Tyndall at the University of Bristol. After a period of teaching, he joined the Chemical Warfare Branch of the Army and served in France in the First World War with the rank of captain.

In 1921 he was appointed to the Admiralty Signals Experimental Establishment at Portsmouth where, after a period of liaison with Dr. B. Hodgson, he took charge of the high-power transmitting-valve development work. It was here that Hughes, with his colleague Goldup, made the first 10 kW silica transmitting valve which successfully demonstrated the possibilities of this type of h.f. generator for naval transmitters. His university training in chemistry proved invaluable in this development. The results Hughes marshalled together in a masterly way in a thesis which earned him a higher degree. As thermionic devices increased, came the necessity for close inter-Services co-operation. A committee was formed, of which Hughes was secretary, and many new valves thereby became common to the three Services. Also, he was a Service representative at meetings of the British Radio Valve Manufacturers' Association and did much to foster a friendly spirit between the Services and the Association, who valued his co-operation most highly.

Later, the Organization for Co-ordination of Valve Development (C.V.D.) was formed for linking industry and the Services. He did valuable work as secretary of sub-committees for important branches of the work, which included the heavy task of recording and circulating data for all standardized valves. Also, during the Second World War he organized new laboratories for special valve work. Hughes was most helpful and friendly in co-operation with his colleagues. He took special delight in observing trials of new valves and in contributing to the solving of difficulties.

For many years he represented C.V.D. on the International Electrotechnical Commission Valve-Standardization Committee TC/39, and in this international setting he was a most valuable member of the Committee and did a good deal to assist in the solution of the many standardization problems. He was also chairman of the British Standards Institution Committee on Valves and Tubes—TLE/5.

He retired, as a principal scientific officer, from Admiralty service in 1955 and then joined the Ministry of Supply on a part-time basis to carry on his work on valve standardization for N.A.T.O. and the Services and liaison with B.S.I. In March 1957 he relinquished this post with the Ministry of Supply but was retained by them as a consultant adviser because of his work with N.A.T.O. It was after returning, apparently in good health, from a fortnight's work in Paris, that he was suddenly taken ill and died after two days' illness.

An active worker in general staff affairs, he was, for many years, Signal School representative for Admiralty superannuation matters for the scientific staff. He was interested in the sports and social activities and enjoyed arranging games and amusing illusions for the children's Christmas parties. He was most happy when on excursions with his wife and family of four children, by whom he is survived.

Hughes joined The Institution as an Associate Member in 1934 and was elected a Member in 1943. He served on the Wireless Section Committee from 1941 to 1944 and was chairman of the Codes of Practice Council Code-Drafting Committee on the Use of Electronic Valves from 1951 to 1958. He was also a Fellow of the Physical Society. His joint paper with H. Morris-Airey and G. Shearing on *Silica Valves in Wireless Telegraphy* was published in the *Journal* in 1927. G. S.

ROBERT WILLIAM HUGHMAN

Robert William Hughman, after having recently recovered from a serious illness, died suddenly on the 23rd June 1958. He was born on the 25th May 1870 and at the age of 19 joined the consulting staff of the late Robert Hammond at Faraday House. Some two years later, when Hammond decided to launch a new electrical weekly, *Lightning* (later to become *Electrical Times*), Hughman joined the editorial staff and started a lifetime of association with the paper.

His promotion was rapid: he became assistant editor in 1895, general manager in 1901 and joint managing director in 1907. There followed an interval during the 1914–18 War when he was commissioned in the 9th Middlesex Regiment, attaining the rank of major. During this service he was seconded for a period to the Royal Flying Corps to carry out work on plane-to-plane communication by wireless telegraphy. He returned to *Electrical Times* after the war, finally retiring from the position of managing director in 1947, after 56 years' service.

Robert Hughman enjoyed nothing better than to talk of the early days of the electrical industry, of which he had a profound knowledge, acquired from an excellent point of vantage. He never tired of reliving the first battles between gas and electricity, the troubles with the granting of Special Orders or the Parliamentary inquiries preceding Private Electricity Acts. In 1896 he had been associated with the formation of the Municipal Electrical Association (later the I.M.E.A.) and also supervised the first regular publication of statistics of the supply industry, which continued from 1892 until suppressed by the censor in 1939. In other fields he was equally far-seeing, and his early advocacy of electric heating in the home is to be found in the volumes of *Electrical Times* before 1914.

With the quiet culture of the Victorian age, Robert Hughman had always made reading his principal hobby and, despite failing eyesight, maintained to the end a close interest not only in the electrical industry, but in current trends of literary and philosophic thought. Although serious in mien, to those who know him well he had at times an impish sense of fun, which is reflected in his earlier writings in *Punch*. He was a good clubman also: a past-president of the Batti-Wallahs, an honorary member of the Dynamicables, and a founder-member of the now defunct Engineers' Club. He was the elder brother of the late Sir Montague Hughman and is survived by a son and two daughters.

He joined The Institution as an Associate in 1898 and was elected a Companion in 1929. R. B.

ROBERT LEE

Robert Lee, M.B.E., who died on the 15th March 1958 at his home at Eastbourne, was born at Haslingden, Lancashire, on the 30th December 1885. He received his technical education at Blackburn Technical School and the Manchester College of Technology and was apprenticed at Darwen generating station, Lancashire.

In 1903 he joined the Stockport Corporation Electricity Department as a switchboard attendant and junior engineer and in nine years progressed to become deputy borough electrical engineer. In 1927 he went to St. Helens Corporation Electricity Department as their borough electrical engineer and manager and after 15 months returned to Stockport Corporation in the same capacity.

In 1932 he became chief electrical engineer and manager of the Borough of St. Pancras Electricity Department and remained there until the industry was nationalized in 1948. He was then appointed sub-area liaison officer by the London Electricity Board and held that position until he retired in 1953.

During his service at Stockport, Lee was responsible for a number of extensions and improvements and had the distinction of being associated with Stockport when it became the first undertaking in North-West England to supply current to the Grid system.

He was chairman of the Electrical Research Association during 1947 and, following the death of the chairman in 1949, became acting chairman for the rest of that year.

He was for many years a well known and respected figure in the municipal electrical engineering world and right up to his retirement from the London Electricity Board was greatly concerned with staff relationship and negotiations. He served on many joint committees, and his work was appreciated by both sides; many trade union representatives expressed their affection for him. As early as 1943 he favoured the merging of electricity and gas and felt that the best interests of the country would be served by the electricity and gas industries being related to each other, instead of being competitors in the same market.

He was an upright man, lively in company and kindly in all his deeds, with a very wide circle of friends. His loss will be deeply felt, not only by his colleagues but by many others in all branches of the electrical industry.

He joined The Institution as an Associate Member in 1928 and was elected a Member in 1934. He was also an Associate Member of The Institution of Mechanical Engineers and was appointed a Member of the Order of the British Empire in 1951. L. H. W.

GERALD McKENZIE STUART SICHEL

Gerald McKenzie Stuart Sichel, B.SC., who died in June 1958, was born in Burghersdorp, South Africa, on the 13th July 1884. His father, Godfrey Sichel, was a banker and man of affairs and a member of the South African Parliament under Cecil Rhodes. His mother, Charlotte, had been born in the old Castle in Cape Town. He was educated at Bishops, the Diocesan College, Cape Town. After serving an apprenticeship in Cape Town, he came with his brothers to Scotland in 1905 and graduated at Glasgow University, where he captained the hockey XI. In 1913 he married Marjorie Scott Bull. He never returned to South Africa. In later years he used to say that *Model Engineer* advertisements emanating from Glasgow, rather than his Scottish blood, determined him to attend Glasgow University. He spent his last long vacation in the British Westinghouse Co.'s works and there conceived the idea of erecting their machinery as his life's work.

In 1908 he took the only job then available with the company—a steam-turbine fitter's. After two years getting acquainted with the company's products, he was taken onto the erection department's staff. His entire career was spent with the one firm. For 7 years he was in charge of all work carried out in Scotland. This was followed by three years on administrative duties at headquarters, whence he was promoted to the most important district, South and South-Eastern England, centred on London. This appointment he held for 29 years, until his retirement in 1956.

His work brought him into close contact with the executives and operators of the power stations in his districts. They, as well as his colleagues, genuinely respected Sichel for his ability and absolute integrity. The younger men who served under him regarded him as the ideal chief: a man who knew precisely what had to be done, would explain the technical reasons in a lucid manner and, if necessary, would take off his coat to show how to do it.

He was a man who carried his Christian principles into his everyday life. To him, duty always came first. His rather limited leisure was devoted to his family, his piano, in which he had contemplated a career before choosing engineering, his books and his garden. Nevertheless, he made time for regular church work, having served as parochial church councillor at St. Mary, Harrow-on-the-Hill, and at Hampstead Parish Church, and for the activities of the British Red Cross Society. He is survived by his widow, two sons and two daughters.

He joined The Institution as a Student in 1908 and was elected an Associate Member in 1912 and a Member in 1944. He had been a member of the London Group Committee and in 1957 was chairman of the National Executive Committee of the Electrical Power Engineers' Association. W. A. C.

ALEXANDER DREW SLOAN

Alexander Drew Sloan, who was born on the 23rd February 1883, died on the 8th June 1958. He was educated at Cheltenham College and began his career with Dick, Kerr and Co., Preston, which later became part of the English Electric Co. Through part-time study at the Harris Institute, he gained a scholarship to Manchester University.

On his return to the Preston works he was appointed assistant to the chief of the A.C. Design Department, a post which he held until 1914, when he was sent to Australia and New Zealand in a technical capacity. Shortly after his return in 1915 he was appointed chief a.c. designer. In 1917 his company, having turned their attention to the manufacture of munitions, guns and aircraft, arranged for Sloan to visit America, and on his return the firm, at the request of the Government, began to manufacture flying boats to the design of the Curtis Aeroplane Co. of Buffalo. In 1918 he was responsible for the design of the first 3000 r.p.m. turbo-alternator for what was then considered to be the high output of 5000 kW.

In 1919 the English Electric Co. was formed, and Sloan was transferred to their London office as assistant designer of large a.c. machines. In 1927 he was transferred to Stafford, by which date turbo-alternators were being built for an output of 30 MW. In 1928 Mr. Sloan visited the Westinghouse Co. at Pittsburgh and on his return was responsible for the first umbrella-type vertical-shaft alternator built in this country, for the Galloway Hydro-Electric Co. He was appointed chief engineer of the English Electric Co. in 1936, which position he held until his retirement at the end of 1947, although he continued in a consultative capacity for a short time afterwards.

He joined The Institution as an Associate Member in 1916 and was elected a Member in 1929. He served on the Joint Committee for Practical Training in 1947–48. A. R. B.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated.

AMERICAN RADIO RELAY LEAGUE

Single Sideband for the Radio Amateur. 2nd ed. West Hartford, Conn., 1958. 12s. 6D.

A COMPREHENSIVE digest of over 50 articles which were originally published in the League's monthly journal, *QST*. The 1954 edition has been revised and expanded to bring the information up to date.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report W/T33 **The Relationship between Relative Humidity and the Moisture Content of Agricultural Products—Preliminary Report** by P. Finn-Kelcey and D. G. Hulbert. 24s. (postage 8D.)

RESULTS are given of an investigation into the equilibrium moisture content of a number of agricultural and horticultural materials in atmospheres of different relative humidities. Recommendations are made for the practical application of the results to drying processes.

BRITISH BROADCASTING CORPORATION

B.B.C. Television—A British Engineering Achievement 2s. 6D.

THIS illustrated publication states briefly how television works and describes the facilities in use by the B.B.C. and also the new Television Centre, near Shepherd's Bush, now under construction. It demonstrates the coverage of B.B.C. television and gives advice on obtaining the best reception. Information on the Eurovision exchange of programmes is also provided. The booklet is obtainable from B.B.C. Publications, British Engineering, 35 Marylebone High Street, London W.1.

BRITISH PRODUCTIVITY COUNCIL

Packaging: Productivity Review 30 London. 5s.

THIS review is devoted to reports about the newest packaging materials and techniques and their potential influence on productivity. A chapter on current trends describes the modern functions of packaging, including protection, sales appeal, convenience, and the saving of time, space and labour.

BRITISH STANDARDS INSTITUTION

B.S. 822: Part 2: 1958 **Terminal Markings for Electrical Machinery and Apparatus.** Part 2—**Terminal Markings for D.C. Traction Motors and Control Equipment** 3s.

SPECIFIES the terminal markings and apparatus coding for traction motors complying with B.S. 173 and d.c. traction control equipment complying with B.S. 2618.

B.S. 937: 1958 **Flexible Cable for Miners' Cap Lamps** 4s. 6D.

A REVISION of B.S. 937: 1940. Test requirements for the various components of the cable have been introduced. Tests for resistance of the sheath to body acids and for the properties of the centre strain cord are also prescribed.

B.S. 2991: 1958 **Electric Dry Shavers** 4s.

APPLIES to the safety of electric dry shavers and of their external accessories, including cables, plugs and voltage-dropping resistor, for voltages exceeding 30 volts r.m.s. a.c. or 50 volts d.c. but not exceeding 250 volts a.c. or d.c.; it does not deal with the performance of the shaver.

B.S. 3015: 1958 **Glossary of Terms Used in Vibration and Shock Testing** 5s.

INCLUDES terms used in the study of the effects of vibration and shock, and in testing equipment in shock conditions. Attention is directed to B.S. 661, *Glossary of Acoustical Terms*, for other terms used in this field.

INSTITUTE OF RADIO ENGINEERS

Bibliography on Medical Electronics. Prepared by the Medical Electronics Center of the Rockefeller Institute. Published by the Professional Group on Medical Electronics, Institute of Radio Engineers, New York, 1958. 18s.

THIS bibliography, which is intended to serve as source material in the general field of medical electronics, has been compiled from a master bibliography at the Medical Electronics Center of the Rockefeller Institute and includes only comparatively recent references. The main section contains arbitrarily numbered references listed consecutively and approximately in subject groups. The subject index which follows gives both author and numerical references. The final section, the author index, is classified only according to the senior author's name.

It is planned to publish annual supplements, which may include abstracts, in future issues of the *I.R.E. Transactions on Medical Electronics*.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

The European Nuclear Energy Agency and the Eurochemic Company Paris, 1958. 12s.

A STEERING Committee for Nuclear Energy was set up by the O.E.E.C. Council in 1956, and this report relates the decisions which led to the establishment in February 1958 of the Nuclear Energy Agency and to the setting up of the first European joint undertaking. Technical studies leading to the development of the European Company for the Chemical Processing of Irradiated Fuels (Eurochemic) are included. The report also contains the proposals now being studied in the field of experimental reactors and power stations.

TECHNICAL PUBLICATIONS *(contd.)*

F.P.E.

La production et la consommation d'électricité en Belgique: Statistiques 1957

STATISTICS concerning the production and consumption of electricity in Belgium for 1957 are presented very attractively, together with photographs, diagrams and graphs. The matter is produced objectively, for purposes of analysis in any direction, and editorial commentaries are kept to a minimum.

The booklet is published by the Fédération Professionnelle des Producteurs et Distributeurs d'Électricité de Belgique (F.P.E.), A.S.B.L., 31 rue Bellard, Brussels.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

Applications, quoting the serial number of the paper, monograph or reprint, as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually—if they do not take the Part of the Proceedings in which it will be republished—are urged to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPER

Recognition of Moving Vehicles by Electronic Means *Paper* 2758 M: *Part B*

T. S. PICK *and* A. READMAN

THE increasing congestion of traffic in London's streets has been a matter of major concern to London Transport for many years, and the maintenance of service regularity in these difficult circumstances has so far been achieved with some degree of success by more supervision of operating personnel.

A method is described of providing more information at a central control point as to the movement of buses, without increasing the road staff, to enable measures to be taken before conditions deteriorate, thus minimizing service irregularities. Details are given of the photo-electronic equipment designed for this purpose.

Although the equipment has been produced to deal with a specific bus-operating problem, it should have many applications in the recording of moving objects.

To be read on the 6th November 1958

MONOGRAPHS

Time Decrease of Permeability in Transformer Steel *Monograph* 313 M

PROF. A. K. SMOLINSKI, DIPL.ING., D.SC., *and* M. ZBIKOWSKI, DIPL.ING.

SOME measurements are described of time decrease of permeability on three types of samples stamped out from 4% silicon hot-rolled transformer steel. The first samples contained severe mechanical stresses. Secondly, samples annealed at 800° C were used, and the maximum time of permeability decrease of about 24 hours was reduced, after annealing, to about 8 hours.

Finally, samples annealed at 1250° C in hydrogen were measured, and the results showed that the time-decrease phenomenon was practically eliminated, according to the theory of Snoek.

Relationship between Weather and Electricity Demand *Monograph* 314 S

M. DAVIES, M.SC., PH.D.

A METHOD is described for statistically analysing the relationship between weather and electricity demand for application to daily operations and to longer-range load estimating. The characteristics of the specific meteorological elements to which the demand has been found to respond are discussed, particularly those affecting heating and lighting demands. The thermal-lag factor appropriate to the delay in consumer response to temperature changes, and the influence of the cooling power of the wind on heating load, are examined. In order to assess the lighting load, observations of the atmospheric transmission of light are used to derive a method for reducing cloud and visibility forecasts to their daylight-illumination equivalents.

Calibration of Inductors at Power and Audio Frequencies *Monograph* 315 M

G. H. RAYNER, B.A.

A BRIEF description is given of the standard inductors at the National Physical Laboratory. The principal characteristics of self- and mutual inductors are considered in relation to their measurement. The methods of inductance measurement at the N.P.L. are described: these include the calibration of mutual and self-inductors, the measurement of their variation with frequency, the a.c. resistance of inductors, and the components of self-capacitance. Emphasis is laid on the precautions necessary to ensure precision.

Interpolation and Prediction of Signals Plus Noise for Infinite and Finite Smoothing Times *Monograph* 316 R

D. McDONNELL *and* R. PERKINS

THE first part is concerned with the choice of the optimum filter for the extrapolation or interpolation of a signal which is contaminated by noise. The problem has been completely solved by Wiener in his book on the subject. The method used here for solving the integral equations is different and leads to the solution for the lagging case without having to approximate $\varepsilon^{-p\tau}$ by the ratio of polynominals in p. Laplace transformations are used and lead directly to the solution.

The second part deals with the solution of the optimum filter when the error is minimized at a particular time after switching on, the averaging being taken over an ensemble.

Reconstruction of the Institution Building

IT was explained in the August *Journal*, p. 465, that the Council had given authority for tenders to be invited for the first part of the work of reconstruction of the Institution building and for a formal application to be made to the Duchy of Lancaster for the grant of the new lease. It was also pointed out that planning of the reconstruction as a whole required that a start be made on the third floor, on completion of which the remainder of the Building Fund would be used for selected parts of the rest of the scheme, in order to give much-needed improvement in the public sections of the building for the time being, until completion of the full scheme became possible.

Members will be interested to learn that the terms of the new lease have been agreed with the Duchy, who have granted authority for the reconstruction work to proceed, and that after consideration of the various tenders submitted for phase 1 of the work, the contract has been awarded by the Council to G. E. Wallis and Sons Ltd., who not only submitted the lowest tender but also undertook to complete the first phase of the work in the shortest time, namely 48 weeks.

A start was made at the beginning of October, and thus the work should be finished in time for the opening of the 1959–60 Session. A small part of phase 1 was, in fact, completed in time for the opening of the present session, as it was found possible to make some alterations in the Library during September—alterations which have long been needed to provide members with better reading facilities in improved lighting conditions.

The rest of the reconstruction scheme consists of two further phases. One of these (phase 2) includes alterations to the Lecture Theatre and the provision of a new Council Room and an additional meeting room on the ground floor. The other (phase 3) consists in building over the areas of the Embankment frontage at basement and ground-floor level to form a larger Common Room, waiting rooms, cloakrooms and lavatories.

The remaining funds available from present resources, after the completion of phase 1, would not, however, be sufficient to cover phase 2, which does not lend itself to subdivision, as the various parts of the work are very closely interconnected, nor would this phase of the work produce the greatest immediate benefit to members using the building. In these circumstances, the Council have decided to follow phase 1 with phase 3, the cost of which can be met from present funds. Accordingly, the architects have been instructed to invite tenders for this phase at an early date in order to ensure continuity of progress.

The Council are confident that phases 1 and 3 together will represent, within the limits of present resources, a substantial improvement of facilities for members in the public parts of the building, in addition to providing the much-needed further office accommodation.

It is the Council's intention, however, to make financial provisions so that the last phase of the work (phase 2) can be undertaken as soon as phases 1 and 3 are nearing completion. This will be in about two years' time; they are encouraged by the improvement in the general economic situation which has already come about during the last few months to hope that more favourable terms will then be available.

In the plans for phase 3, provision is included for improvement of the speech-reinforcement equipment and other facilities in the Lecture Theatre, in order to bring all the arrangements for meetings fully up to date. In fact, the first steps towards better speech reinforcement have already been taken by modifying the existing equipment so that further data will be available before the final design is settled.

Forthcoming Events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and Monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card.

October 1958

U **16** *Thursday* R. A. MARRYAT, B.SC.(ENG.) Chairman's Address 'Installation Engineering'*

I **20** *Monday* G. R. NOAKES will open a discussion on 'The Presentation of Electrical Science in Schools' before the Education Discussion Circle† (At 6 p.m., tea at 5.30 p.m.)

* No advance information will be available
† No advance information will be available and no Press report will be permitted

R **22** *Wednesday* G. MILLINGTON, M.A., B.SC. Chairman's Address 'Random Thoughts of a Propagation Engineer'*

R **27** *Monday* J. SWAFFIELD, PH.D., B.SC.(ENG.), *and* D. L. RICHARDS, B.SC.(ENG.) 'Rating of Speech Links and Performance of Telephone Networks' (Paper No. 2666 R) *Synopsis:* June 1958
D. L. RICHARDS, B.SC.(ENG.), *and* J. SWAFFIELD, PH.D., B.SC.(ENG.) 'Assessment of Speech-Communication Links' (Paper No. 2605 R) *Synopsis:* April 1958

M **28** *Tuesday* D. T. N. WILLIAMSON will open a discussion on 'Electronic Control of Machine Tools'†

S **29** *Wednesday* D. P. SAYERS, B.SC. Chairman's Address 'Art, Craft and Rampart'*

November 1958

M **4** *Tuesday* R. C. M. BARNES, B.SC.(ENG.), *and* J. H. STEPHEN, PH.D. 'Operating Experience with a Transistor Digital Computer' (Paper No. 2593 M) *Synopsis:* April 1958
D. ELDRIDGE, B.A. 'A New High-Speed Digital Technique for Computer Use' (Paper No. 2672 M) *Synopsis:* June 1958

O **6** *Thursday* T. S. PICK, B.SC.(ENG.), *and* A. READMAN 'The Recognition of Moving Vehicles by Electronic Means' (Paper No. 2758 M) *Synopsis:* October 1958

* No advance information will be available
† An abstract will be available in advance

November 1958 (*contd.*)

I **10** *Monday* H. G. F. GAMBLE will open a discussion on 'Are Safety Factors and Appliances Adequate?'*

M **11** *Tuesday* Section Dinner (at the Café Royal)

U **13** *Thursday* (In conjunction with the British Nuclear Energy Conference) J. W. BINNS *and* W. J. OUTRAM, M.ENG. 'Electrification of the U.K.A.E.A. Industrial Group Factories' (Paper No. 2698 U) *Synopsis:* August 1958

M **18** *Tuesday* L. A. THOMAS will open a discussion on 'Ferroelectrics'†

R **19** *Wednesday* J. REDMOND. Lecture on 'Problems of Television Recording†

E **20** *Thursday* K. R. STURLEY, PH.D., B.SC., will open a discussion on 'What is a Cultured Engineer?'* (At 6 p.m., tea at 5.30 p.m.)

* No advance information will be available and no Press report will be permitted

† An abstract will be available in advance

R **22** *Saturday* Section Soirée (at the R.A.E., Farnborough)

R **24** *Monday* J. S. SEELEY, B.SC.(ENG.), PH.D., *and* J. BROWN, M.A., PH.D. 'The Use of Dispersive Dielectrics in a Beam-Scanning Prism' (Paper No. 2735 R)
J. S. SEELEY, B.SC.(ENG.), PH.D. 'The Quarter-Wave Matching of Dispersive Materials' (Paper No. 2736 R)
A. CARNE *and* J. BROWN, M.A., PH.D. 'Theory of Reflections from the Rodded-Type Artificial Dielectric' (Paper No. 2742 R)

S **26** *Wednesday* L. L. ALSTON, B.SC.(ENG.), PH.D., *and* PROF. F. M. BRUCE, M.SC., PH.D. 'Investigations of Power-Follow Current Phenomena using a Synthetic Power Source' (Paper No. 2707 S)
L. L. ALSTON, B.SC.(ENG.), PH.D. 'The Impulse Initiation of Arc Discharges' (Paper No. 2708 S)

U **27** *Thursday* Symposium of papers on 'The Provision of Adequate Electrical Installations in Buildings' (see p. 572)

LIBRARY ACCESSIONS

BOOKS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BARTENSTEIN, R., and RACHEL, A. (Editors) 621.315.027.3

Die 400 kV-Forschungsanlage Rheinau. Teil II—Koronamessung (The Rheinau 400 kV research plant. Part II—Corona measuring)

Heidelberg, 400 kV-Forschungsgemeinschaft e.v., 1958. pp. 139. 30 × 21 cm

This further account of the authority's research work refers to corona investigations, explaining the apparatus used and discussing the results obtained.

BRIDGERS, H. E., SCAFF, J. H., and SHIVE, J. N. (Editors) 621.314.7

Transistor Technology. Vol. 1*

London, Van Nostrand, 1958. pp. xxxvii, 661. 23 × 15 cm. £6 11s. 6d.

A book by members of the staff of the Bell Telephone Laboratories who have been actively engaged on transistor production. It deals with the manufacture, testing and reliability of transistors. Two further volumes are promised. This book was reviewed in the September Journal, p. 512.

CALDWELL, S. H. 621.316.3

Switching Circuits and Logical Design*

London, Chapman and Hall, 1958. pp. xvii, 686. 24 × 15 cm. £6

This is a detailed treatment of the subject, beginning with a discussion of switching algebra and a consideration of switching circuits as various forms of contact networks. It considers electronic and other switching components, special circuits and switching codes. The book will be reviewed in a future issue.

COSGRIFF, R. L. 621–52

Nonlinear Control Systems*

London, McGraw-Hill, 1958. pp. vii, 328. 24 × 16 cm. £3 10s.

Gives a short treatment of linear theory, illustrated by worked examples. It then deals with frequency response of non-linear systems, linear equations with periodic coefficients, and the application of statistical methods. There is a final chapter on logical circuits as control elements. The work will be reviewed in a future issue.

DOUGLAS, A. 681.2

An Electronic Organ for the Home Constructor*

London, Pitman, 1958. pp. x, 100. 22 × 14 cm. 15s.

Gives simple, straightforward, but detailed instructions for constructing and tuning an inexpensive instrument suitable for the home or even a hall or church.

DOVER, A. T. 621.315.3

Power Wiring Diagrams. A Handbook of Connexion Diagrams of Control and Protective Systems for Industrial Plants. **4th ed.**

London, Pitman, 1958. pp. xvi, 191. 17 × 11 cm. 16s.

Covers motors, control systems and apparatus, generators, transformers, and rectifiers, including those for arc-welding equipment, instruments and protective systems. It will be reviewed later.

EHRENBERG, W. 621.315.59

Electric Conduction in Semiconductors and Metals*

Oxford, Clarendon Press, 1958. pp. vii, 389. 24 × 16 cm. £3 3s.

Intended as an introduction to the physics of semiconductors, with emphasis on their electrical properties, for readers with a good grounding in physics. It will be reviewed in a future issue.

FARROW, H. E. 621.396.11

Long-Wave and Medium-Wave Propagation

London, Iliffe, 1958. pp. 39. 22 × 14 cm. 4s. 6d.

A booklet based on a series of lectures in the B.B.C. Training Department to students specializing in the operation and maintenance of transmitting stations.

FLÜGGE, S. (Editor) 53

Handbuch der Physik. Band VI—Elastizität und Plastizität (Handbook of physics. Vol. VI—Elasticity and plasticity)

Berlin, Springer, 1958. pp. vii, 642. 25 × 17 cm. £9 18s. 4d.

FRIEDLANDER, F. G. 534

Sound Pulses*

Cambridge, Cambridge University Press, 1958. pp. xi, 202. 22 × 14 cm. £2

A mathematical treatment of the theory of sound pulses.

LIBRARY ACCESSIONS *(contd.)*

GIBBS, W. J. 517

Conformal Transformations in Electrical Engineering*

London, Chapman and Hall, 1958. pp. viii, 219. 22 × 14 cm. £2 5s.

Early chapters cover the elements of field theory and complex numbers. The transformations lead up to those involving elliptic functions, practical examples being given at each step. The book will be reviewed in a future issue.

GRIVET, P. 537.533.7

Optique Electronique. II—Microscopes, Diffractographes, Spectrographes de Masse, Oscillographes Cathodiques (Electron optics: microscopes, diffractographs, mass spectrographs, cathode oscillographs)

Bordas, 1957. pp. 339. 24 × 16 cm.

HOLM, R. 621.3.066.6

Electric Contacts Handbook*

Berlin, Springer, 1958. pp. xviii, 522. 24 × 16 cm. £4 10s.

This is a very much enlarged edition of the author's Electric Contacts, *published in 1946.*

HOOPER, J. E., and SCHARFF, M. 537.59

The Cosmic Radiation*

London, Methuen, 1958. pp. 172. 17 × 11 cm. 12s. 6d.

This monograph gives a description of the microscopic phenomena of the cosmic radiation and of the development of the radiation in its passage through the atmosphere. It will be reviewed in a future issue.

HOUGHTON, H. G. (Editor) 551.59

Atmospheric Explorations.* Papers of the Benjamin Franklin Memorial Symposium of the American Academy of Arts and Sciences

London, Chapman and Hall, 1958. pp. x, 125. 24 × 15 cm. £2 12s.

A collection of five papers read at the Symposium in 1956. They cover the electrification of cloud and raindrops, the formation of electric charges in thunderstorms, meteorology of the upper atmosphere, and radio scattering. This book will be reviewed in a future issue.

JAMES, F. E. S., and JAMES, E. P. S. 347.7

Copinger and Skone James on the Law of Copyright including International and British Commonwealth Copyright, with the Statutes and Orders Relating thereto and Forms and Precedents. **9th ed.**

London, Sweet and Maxwell, 1958. pp. xxxvi, 917. 26 × 16 cm. £5 10s.

The edition takes into account the Act of 1956.

KLEEN, W. 621.396.029.6

Einführung in die Mikrowellen-Elektronik. Teil I—Grundlagen (Introduction to microwave electronics. Part 1—Fundamentals)

Zürich, Hirzel, 1952. pp. xix, 300. 24 × 16 cm

KLEEN, W., and PÖSCHL, K.

Einführung in die Mikrowellen-Elektronik. Teil II—Lauffeldröhren (Introduction to microwave electronics. Part 2—Magnetron travelling-wave tubes)

Stuttgart, Hirzel, 1958. pp. x, 192. 24 × 16 cm

Based on a series of lectures to senior students. Part 1 is a review of the whole field of microwave electronics from the point of view of fundamentals. Part 2 discusses travelling-wave tubes.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in CAPITALS is the month in which a paper or monograph was published individually.

PART A. POWER ENGINEERING (OCTOBER 1958)

BERYL M. DENT, M.SC., E. R. HARTILL, B.SC.(ENG.), AND J. G. MILES, B.SC.(ENG.). PAPER NO. 2452 S, DECEMBER 1957 **A Method of Analysis of Transformer Impulse-Voltage Distribution using a Digital Computer** *May 1958*

Discussion on **A Deep Electrolytic Tank for the Solution of 2- and 3-Dimensional Field Problems in Engineering** before the North-Western Measurement and Control Group

D. L. SMART, B.SC.TECH., AND J. J. L. WEAVER. PAPER NO. 2457 U, JANUARY 1958 **The Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating** *July 1958*

Discussion on **Brushless Variable-Speed Induction Motors** before the Mersey and North Wales Centre

K. L. STRETCH, M.A. PAPER NO. 2594 S, APRIL 1958 **Operational Experience at Calder Hall** *July 1958*

H. V. PUGH. PAPER NO. 2445 S, NOVEMBER 1957 **The Generation of Electricity in the London Area** *July 1958*

Discussion on **Electric Control of Stage and Television Lighting** before a joint meeting of the North-Western Utilization Group and the North-Western Radio and Telecommunication Group

K. G. CORLESS, B.ENG., AND A. S. ALDRED, M.SC. PAPER NO. 2673 S **An Experimental Electronic Power-System Simulator** *June 1958*

P. J. RYLE, B.SC.(ENG.). PAPER NO. 2683 S **Transmission and Distribution at 66 kV and Over: Overhead Lines** (*Review of Progress*)

P. LOMB, DIPL.ING., AND G. ELLESWORTH, B.SC.(ENG.). PAPER NO. 2696 U **A Generalized Locus Diagram for Induction Motors** *October 1958*

PROF. T. V. SREENIVASAN, B.E., M.SC.TECH. PAPER NO. 2697 **Application of a Variable-Reactor/Capacitor Combination for Reversing and Controlling the Speed of Polyphase Induction Motors** *October 1958*

Discussion on **Earth Electrode Systems for Large Electric Power Stations** before the East Midland Centre and the Western Supply Group

J. E. BROWN, B.SC., PH.D., AND R. L. RUSSELL, M.SC. PAPER NO. 2703 M **Bridge Methods for Determining Symmetrical Components of Current, Voltage and Power, with Special Reference to Electrical Machinery** *October 1958*

J. E. BROWN, B.SC., PH.D., AND R. L. RUSSELL, M.SC. PAPER NO. 2704 U **Symmetrical-Component Analysis applied to Phase Convertors of the Ferraris–Arno Type** *October 1958*

Discussion on **Earthing of Low- and Medium-Voltage Distribution Systems and Equipment** before the North-Eastern Centre

Discussion on **Electricity in Modern Commercial Horticulture** before the South Midland Supply and Utilization Group, the Southern Centre and the Northern Ireland Centre

Discussion on **The Measurement of Earth-Loop Resistance** before the West Wales Sub-Centre and the North Lancashire Sub-Centre

PART B. RADIO AND ELECTRONIC ENGINEERING (SEPTEMBER 1958)

See the Journal for September 1958, p. 519

PART C. MONOGRAPHS (SEPTEMBER 1958)

See the Journal for September 1958, p. 519

Elections and Transfers

The following elections and transfers approved by the Council became effective during August and September 1958

ELECTIONS

Member

KLEWE, Hans Robert Juluis, DR. PHIL.

Associate Members

ADDISON, John Richard, B.SC.(ENG.)
ALDOUS, Peter
AL-RUBAYI, Nouriddin Abdullah, B.SC., M.SC., PH.D.
BELL, Air Comm. Cedric Arnold, B.A., R.A.F.
BELL, Richard
BIRMAN, Gerhard, DIPL.ING.
BIRNINGHAM, Peter James
BUCKLEY, George William, M.A.
CARTER, Charles Herbert James
CHALCRAFT, Ernest Stanley
CLEMETT, Colin John, B.SC.
DOUGLAS, William Sholto, B.SC.
ELLIOTT, Terence Peter
FFITCH, Kenneth William, B.SC.(ENG.)
FIDDES, Ronald George, B.SC.(ENG.)
FOGO, James, B.SC.
GOODALL, William George
GREEN, Michael William Anders
HARRIS, Charles Henry
HARRISON, James Derrick
HART, Michael Norman, B.SC.(ENG.)
HODGES, Frank Lewis
KAPOSI, Janos Ferenc
KELSON, Donald
KENNEDY, Robert Simpson
KOPICKA, Josef, DIPL.ING.
LOBLEY, Arthur, M.ENG.
MACLEOD, John Alexander
MILLER, Archibald Cochrane
MUNDAY, Donald Brearley
OLDHAM, Robert Alexander, B.A.SC.
PASK, Lt.-Cmdr. Cyril Alexander, R.N.
PHILIPS, Modale Chacko, B.SC., B.SC.(ENG.)
PHILPOTT, Bertram Thomas
PLATT, Derek William, B.SC.(ENG.)
PRICE, Ernest Maurice, M.SC.TECH.
RABY, Ronald Ernest
READ, Kenneth George Trevor
RENNICK, Dennis Patrick Kingston
SARKAR, Ananta Bikram, M.SC.
SCOTT, William Leslie
SEN, Sachindranath
SKINGLE, Eric Edward
SLAUGHTER, Raymond Jeffrey, B.SC.
STONESTREET, Lt.-Col. Maurice, B.SC., R. SIGNALS
THOMPSON, Miss Jane Cicely, M.A.
TINNEY, Sean, B.E., B.SC.
WALKER, Peter Howe, PH.D., B.SC.(ENG.)
WALLER, Richard de Warrenne
WARREN, Percy Harold
WEINHARDT, Josef
WELSH, Martin Edward, B.SC.
WOODROFFE, Albert William

Associates

BALLINGALL, James Macdonald
ELLORY, Frederick Ronald
ENDICOTT, Frederick William
FERRIS, Reginald Redvers
GARGINI, Eric John
GHOSH, Bimal Chandra
GILES, Henry
GRESHAM, Kenneth Carter
HALL, Harold
HARRIS, Roland Owen
HUMPHREY, Frank John
KIRKLAND, Stanley
PILGRIM, Anthony John
PLANT, George Cecil Ross
SANDBERG, Olaf James
STEVENS, Richard Norton
WATERS, Peter Henry
WATTS, Roy James

Companion

VIDLER, Ernest John

TRANSFERS

Associate Member to Member

BAKER, Sidney Henry, B.SC.(ENG.)
BOND, Richard
BREWER, Sydney Roy Britton, B.SC.(ENG.)
BRIGHT, Harold, M.A.
BRUCE, William Ramsay
COLGAN, Anthony Joseph
DESAI, Rasendra Pinakiprasad, B.SC.
EARP, Charles William, B.A.
EAST, Frederick Henry, B.SC.
FISHER, Lewis
FRENCH, Henry William, B.SC.
GAZE, Philip Elliot, B.A.
GOUGH, Miss Kathleen Agnes, B.SC.
HALL, Richmond Ernest
HAMER, Edward George, B.SC.(ENG.)
HARMER, Leslie Brooke
HOLLAND, Geoffrey Miles
HORLEY, Frank Albert
JONES, Gwilym Owen, B.SC.
JOYNER, Walter Stanley
KRZYCZKOWSKI, Lt.-Col. Antoni, DIPL.ING.
KUMAR, Nelamangalam Chinniah Sasi, B.SC.(ENG.)
LOCKE, Ronald Arthur, B.SC.(ENG.)
LUCAS, John Harold, B.SC.(ENG.)
MARTIN, Alexander Allardyce Blyth, B.SC.
MONCKTON, John
PORTER, Arthur, M.SC., PH.D.
ROBINSON, Eric Ernest
ROLLS, Thomas Burnand, B.A.
SMITH, Miss Dorothy
SYKES, Clifford, B.SC.
TAYLOR, Charles Ronald, M.SC.
TOWILL, Sydney, B.SC.(ENG.)
TYLER, Maj.-Gen. Leslie Norman, C.B., O.B.E., B.SC.(ENG.)
WALLACE, Norman Mordaunt
WHITE, Robert Williamson, B.SC.
WILDE, Wilfred, B.SC.(ENG.)
WILLIAMS, Benjamin Jones

Associate to Associate Member

CLARIDGE, Lt.-Col. Geoffrey Maximilian Lawrence, R. SIGNALS
EVANS, Richard
SMITH, Francis Woodyear

Graduate to Associate Member

ACKERMAN, Kenneth Rodney, B.SC.(ENG.)
ALDRIDGE, Edward Ernest, B.SC.(ENG.)
ANDREWS, Jork David
ARMITAGE, Harry
ARMSTRONG, Robert, B.SC.(ENG.)
ASLETT, Raymond Gwyther
ASPINALL, John Wilkinson, B.SC.TECH.
ATKINSON, John Brian, B.SC.(ENG.)
ATKINSON, Wallace Edward
BAILEY, John Andrew, B.SC.TECH.
BAINES, Anthony Peter
BAKER, Donald Montgomery, B.E.
BARCLAY, John Derek
BARRETT, Robert, B.SC.
BEAUMONT, Clement
BELL, John Ramsay
BENNETT, Anthony Frederick
BENNETT, Emanuel Henry
BETTLEY, Gerald
BHARGAVA, Rajendra Nath, B.SC.(ENG.), M.A.SC.
BICKERSTAFF, Francis John
BILLINGS, Alan Reginald, B.SC., PH.D.
BLACK, John Wilson, B.SC.
BLOMFIELD, Peter Francis
BOAS, Sidney Clifford, B.SC.(ENG.)
BONIWELL, Colin Ivor Jenks
BOYSON, Ambrose Herbert
BRETT, Alfred Donald
BROOME, Eric
BROWN, Alexander Livingston
BROWN, Thomas Denham Taylor
BUCHANAN, Alexander Ross
BUCK, Gordon Alan
BUXTON, Simeon Alan Earp
BYRNE, John Vincent, B.E.
CARNEGIE, James, B.SC.
CASTLE, John Lucas
CHAPMAN, Kenneth Samuel, B.SC.(ENG.)
CHAPMAN, Maurice John
CHESTER, Anthony John, B.SC.(ENG.)
CLARKE, Douglas Malcolm, B.SC.(ENG.)
CLYNE, Alexander
COCKBURN, Ronald John, B.SC.(ENG.)
COLE, John
COLHOUN, Robert Sidney, B.SC.
COLLINS, John
COOKE, Roy Arthur Northcote
CUTLER, Richard Deryck
DAVIDSON, John
DAVIES, Arthur Emlyn
DAVIES, Thomas Armstrong, B.SC.
DEAN, Gerald Bernard, B.SC.(ENG.)
DE KRETSER, John Henry Gear
DINES, Derek
DINSDALE, John Philip
DOW, John Paton
EGENES, Harold Oscar, B.SC.(ENG.)
ELKINGTON, David Hyla
ELLIOTT, Anthony Charles
EVANS, William Davidson
EVERARD, Derek William, B.SC.(ENG.)
FIELDHOUSE, Frederick Noel
FINES, Ronald Russell, B.SC., PH.D.
FINLAY, William Joseph Kenneth, B.SC.
FORSTER, Creighton Bishop
FOULKES, Frank Moulton, B.SC.
FOZARD, Basil, B.SC.(ENG.)
FULLFORD, Albert Edwin
GAYTER, Gordon James
GIBSON, John Kenneth, B.SC.
GILL, Hedley
GLASS, Reuben Casper, M.A., B.SC.
GRAY, Bertram Charles
GRAY, Robert
GREASLEY, Tom
GRIFFITHS, Stewart George
GYI, Maung, B.SC.
HAIGH, Gordon Albert
HANNAH, Douglas Roberts
HANSON, William Leslie
HARDING, Ronald
HARMAN, Jack James
HARRIS, Douglas James, B.SC.(ENG.), PH.D.
HARVEY, Gordon, B.SC.
HECKFORD, David Clifford Durrant
HICKMAN, Herbert Charles, B.SC.(ENG.)
HIRST, David George Lumsdaine, B.SC.
HODGETTS, Graham Benson, M.SC.
HODGKINSON, Peter Cliffe, B.SC.TECH.
HOLDEN, Albert
HOUSLEY, Gordon James Thomas Peach
HUGHES, John Grosvenor
HUGHES, Jonathan Francis
JACK, Gerald Alan Stanley, B.SC.(ENG.)
JACKSON, William David, B.SC.
JOHNSON, Oliver Sanders, B.SC.
JONES, David James, B.SC.
KIRK, Donald, B.ENG.
KNOWLSON, William John
LAMONT, John Alexander
LAW, Derek, B.SC.(ENG.)
LAWRENCE, Reginald Bernard
LEAMAN, James
LOE, Derek Arthur
LUCKETT, Thomas Charles
LUDBROOK, Allan, B.SC.TECH.
McCONNELL, Eric James
McMASTER, Joseph, B.SC.
MANN, Leslie Roy, B.SC.
MEADS, Edward Frederick
MERLO, David, B.SC.(ENG.)
MITCHELL, William Robertson
MOFFAT, James Forbes
MOON, George Natal Reginald, B.SC.
MORTIMER, Kenneth Watts
MORTIMER, Roger Barry
MOUND, Norman John
MOUTELL, Leslie George
NEW, Harry George
NEWMAN, Peter Colin, M.A.
NEWSUM, Peter
NICHOLSON, George Duncan, B.SC.
NORRIS, Thomas Eric, B.SC.
NORTH, Edwin James
NORTON, David John
OKOLI, Gabriel Chukwura
OLD, John
OSBORNE, Ralph Irving, B.SC.
OWERS, Lt.-Cmdr. Clifford, R.C.N.
PARROTT, Kenneth Gordon, B.SC.
PATERSON, Iain Walter Forrestal, B.SC.
PATTON, Hugh William, B.SC.
PEPPER, Edward John
PERING, John Stephen
PIERSON, John, B.SC.
PITSTOW, Dennis John, B.SC.(ENG.)
POOLER, William John Robert Hollies M.A.
POULTER, Arthur Frederick
PRADHAN, Keshav Balkrishna, B.SC.
PRESCOTT, Alfred
PUGH, James Reginald, B.A.
RAWSON, Eric
RICHARDS, David Vivian, B.SC.(ENG.)
RIGBY, Norman
ROBINSON, Norman
ROSS, Duncan Alexander, B.SC.
ROTHWELL, Kenneth
RYAN, John Charles
SERRELS, George Alfred, D.F.C.
SHAW, Kenneth Allan
SIMON, John Hooson
SINCLAIR, John Paton, B.SC.
SKELTON, Nathaniel Pollock
SMITH, Albert
SMITH, John William
SMITH, Lewis, B.SC.(ENG.)
SMOUT, Ralph
SNIEGON, Karol
STEPHENS, John Hall
STEPHENSON, William Russell, B.SC.TECH.
STEWART, George Frank, B.SC.
STREETER, James Ainslie
STRONG, Warren Sydney, B.E.
SUTTON, Gerald Brian
SYKES, Donald
TAYLOR, Donald Pettitt, B.SC.(ENG.)
TAYLOR, John Charles Browne
TENNET, William
THOMPSON, Geoffrey
THOMSON, James David, B.SC.(ENG.)
TILBURY, Robert Joseph
TINKER, Donald
TIPPETT, Kenneth Guy Martin, B.SC.(ENG.)
TOMKINS, Alan Gordon, B.SC.
TOMS, James Edward, B.SC.

Elections and Transfers

TRANSFERS

Graduate to Associate Member (contd.)

TOWSE, Harold James, B.SC.(ENG.)
TRAHEARN, Peter
TRICKER, Geoffrey Richard
TROST, John Rudolf, B.SC.(ENG.)
TURK, Ian Ludwig, B.SC.(ENG.)
TYM, Samuel
UPSTON, Raymond Alfred Ellis
VENKATESWARAN, Sankara, B.SC., M.A.
WALL, Peter Kenneth, M.SC., B.SC.(ENG.)
WHITENSTALL, Aubrey Stephen
WHITING, William George, B.SC.
WICKEN, Percy Denis, B.SC.(ENG.)
WILLOUGHBY, Arthur Linton
WILSON, Harold
WISHART, Lt. John Neil, M.A., R.N.
WOLFF, Charles Henry, B.SC.(ENG.)
WRIGHT, Thomas
YOUNG, Norman
YOUNG, William James, B.SC.

Student to Associate Member

CREWE, Frederick Owen Trevor
GETGOOD, John Thomas Watson, B.SC.
KENNEDY, Rudy Ronald, B.SC.(ENG.)
KING, Brian Edmund, B.SC., PH.D.
PERCIFULL, Robert Francis
PERRY, Brian Lake, B.SC.(ENG.)

The following elections and transfers approved by the Council are effective from the 11th September 1958

ELECTIONS: 1st LIST

Graduates

AHMED, Syed Misbahuddin, B.SC.
ALLANAH, Vincent Eric Nwokocha
ANDREWS, Lawrence Harry
ARCHER, Kenneth Charles
ASH, Dennis Raymond Thomas
ASHTON, Frank
AYLWARD, Conrad John
BACON, Donald
BAULK, Kenneth
BEAN, Andrew Robertson, B.SC.(ENG.)
BELL, Clifford, B.SC.
BEWICK, Alan
BLACKER, John
BRIGGS, Alan
BRIGGS, Ronald
BROWN, Paul Trevor Robinson, B.A.
CAVANAGH, William Norbert
CHAPPELOW, Robert Teasdale
COLE, Oswald Elliott, B.SC.(ENG.)
DANIEL, Walter Lynn, B.SC.
DAVIES, Brian Thomas
DAVIES, Meirion, B.SC.
DEAN, Geoffrey John, B.E.E.
DIGNUM, Raymond, B.SC.
DISLEY, Charles Geoffrey
DIXSON, Peter Leonard
DOCHERTY, Archibald Pollock, B.SC.
DONOGHUE, Joseph Keith
DUCKER, Peter Gerald
DUCKWORTH, Herbert
DUFFIELD, Albert Charles
ELLENDER, Edward Arthur, B.SC.
ELLIOT, Brian Lawrence
FALLON, Eric, B.SC.TECH.
FANTHOME, Ernest Oliver
FARMER, Michael William John
FILDES, Colin
FLANAGAN, Kenneth
FLETT, Arthur Donald
FLOCKHART, Desmond Gordon
FOOTT, Douglas Edward
FORD, Donald Richard
FOX, Eric
FRYER, Anthony Fred
FUTERS, Stephen
GIBBARD, Michael John, B.SC.(ENG.)
GIBBS, Eric Walter
GRIFFITHS, Derek Gwyn
HARRISON, Arthur Edward
HASELL, Barry Ian
HAWKINS, Arthur Dennis
HILLEL, Jamil
HINDLE, Maurice James Hulbert
HODGES, Alan Russell
HOLLINGWORTH, John
HOSKER, Donald
HOWARTH, Royden
HUME, Brian Joseph
INGS, Warner Richard
JAEGER, Jean-François, B.A.
JAMES, Edward Walton
JINMAN, William John Thomas
JOHNSON, Ronald
JONES, Paul Frederick
JONES, Peter Raymond
JONES, Roger Cecil Gresley
KAVASJI, Behram Perofshaw
KINGSLEY, Robert Wallis, B.E.
KOCSIS, Ferenc
LATHAM, Raymond Samuel
LEE, James Alexander William
LEWIS, Robert Lindsay
LINE, Lt. Timothy Charles, M.A., R.N.
LOCK, Colin Sidney
LUBBOCK, Albert John Kenneth
LUDLOW, Harold Alfred
McDONALD, Aubrey John Cowpe
McGUCKIN, John Nicholas
MANSFIELD, Robin James
MEHTA, Dinkar Shantilal
MILES, Dodwell Rees
MORRIS, Ian Glynn
MORRIS, John David, B.A.
MUNEGATO, Antonio
NEWBY, Bruce William George, B.SC.(ENG.)
NICOL, Richard Peacock
O'BRIEN, Patrick Martin, B.E.
O'NEALE, Clifton George
PAGE, Alfred Henry, B.SC.
PALMER, Thomas Robert, B.E.
PATON, John
PAYNE, Geoffrey Reginald
PEARSON, Donald Edwin, B.SC.(ENG.)
PENDERGAST, Albert Anthony
PINE, Charles Stephen Floyde, B.SC.
POCOCK, John Arthur
POLKINGHORNE, Roy, B.A.
POND, Ronald Douglas
PRINGLE, Keith
RAMJOHN, Merlyn Rahaman
REAKES, Paul Tolley, B.SC.(ENG.)
RICHARDSON, Alan Francis
ROBINSON, William
ROPER, David Taylor
ROYAL, Thomas Ian, B.SC.(ENG.)
RUSSELL, Keith Anthony Spencer
SARKAR, Pradyot Kumar, B.SC.
SCHOFIELD, William
SCHÜTTE, Capt. Paul Thomas, B.E.
SEMPLE, William Yuille
SHARP, Dennis
SHORT, Edwin George Charles
SHORT, Raymond
SIMS, Edward Henry
SMITH, James Bernard
STERANKA, Petro
TIMM, Douglas Copestake
TOMLINSON, Frank
TOMS, Harold Robert
TRAIN, David, B.SC.
WATKINSON, Stephen
WATSON, John
WEST, Gordon Albert
WESTERN, Peter William Robert
WESTLAKE, Terence John Martin
WHITE, George Ernest
WIELEBINSKI, Richard, B.E.
WILDING, George Edward
WILKINSON, Ronald Milnes
WILLIAMSON, Eric Childs
WOOLLISCROFT, Dennis Henry

Students

ADAMS, Norman Powell
AHMAD, Bashir
ALLMARK, Alan
AMATYAKUL, Koses
ARIWODO, Isaac Obinnaya
BASS, Robert John
BATTEN, John Anthony
BEST, Cyril Frank
BLAKE, Nicholas Seymour
BUSS, Brian Peter
CLAREY, William Joseph
CONSTABLE, John Leslie
COOK, Peter
CRADDOCK, Malcolm Steele
CURSETJEE, Kaye Dady, B.SC.
DIXON, Keith Bernard
DSANE, Alexander Sowah
EASTON, James
ELLWOOD, Michael Robin
FARNAN, John William
FEEST, Michael John
FISK, Robert Malcolm
GOLDIE, Samuel David
GUPPY, Colin Byron
HALLETT, John
HASKARD, Malcolm Rosswyn
HILL, David Roy
HILL, James William
HODGSON, Bryan Anthony
IVES, Charles Victor
KERESZTURY, Laszlo
LIEW, Hing Ng
LONG, David Peter
MARLOW, Stanley Frederick
MATIN, Shaikh Azizul, B.E.
MEADE, Brian Alexander
MENDIS, Liyana Belson
MIDDLEMISS, John Johnston
MILLER, Keith English
MORTON, Alan
MOULE, Terence
MOXON, Leonard Reginald Ernest
MUKHERJEE, Phanindra Nath, B.SC.
MUKHERJEE, Samir Kumar, B.SC.
OWENS, Victor Thomas
PREES, Michael Ronald
ROBERTS, Arthur Vernon
ROBLESS, Denis Adrian, B.SC.
SAIN, Oscar Maung
SARSON, William Charles Turner
SETTER, Geoffrey Charles
STANWAY, William Arthur
SURTI, Kantilal Khushaldas, B.E.
THOMPSON, Neil Arthur
TUCK, Kenneth Richard
TUTTON, Peter John
VICKERS, Leslie David
WALLACE, David Ross Elliott
WALTON, David
WHITESIDE, John Johnston
WRIGHT, Gordon
WRIGHT, John Thomas Matthew
WYLIE, Charles Frederick

TRANSFERS: 1st LIST

Student to Graduate

BALDRY, Ronald Herbert, B.SC.
BENNET, Peter, B.SC.
BLOORE, John
BRINSLEY, Clive, B.E.
COUTTS, William Donald
CURRIE, George Alisdair Cockburn, B.SC.
CUTHBERTSON, Norman Edward McOuat, B.SC.
DAVIES, Gwynfor
DRYBURGH, Eric Campbell, B.SC.
DURANT, Alan John, B.SC.
ELLIOT, Ian Emmerson
FARRIER, Norman Langford
GWYTHER, Harold Francis Garfield, B.SC.TECH.
HAMILTON, Robert, B.SC.
HEALEY, James Vaughan
HOGGARD, William Ian, B.E.
HUNT, Kenneth Bruce, B.SC.(ENG.)
JAMIESON, John Anthony, B.SC.(ENG.), M.S., PH.D.
JOHNSON, Michael
KERMAN, Francis Edward, B.ENG.
MASON, Gerald Alfred, B.SC.(ENG.)
MEE, David Geoffrey
MEHTA, Darayes Bahadur, M.SC.(ENG.), B.E.
MIRCHANDANI, Ram Kishinchand, B.SC.
MORRIS, Derek Malcolm
MUKHERJI, Archi Deb, B.SC., B.SC.(ENG.)
PASCALI, Petros Photiou, B.SC.(ENG.)
PAYLOR, David Marsden
PHILLIPS, Gwilym John
RALEY, David John
SHORTLAND, Michael Geoffrey, M.SC.TECH.
SPINNEY, Glen Francis
THOMAS, David Gordon, B.SC.(ENG.)
TIVEY, Alastair Michael, B.SC.(ENG.)
VENN, Albert William John
WATSON, David Lancaster, B.SC.
WILCOCK, Arthur
WILLIAMS, Gerald Austen
WILLIAMS, Ronald Henry, B.SC.(ENG.)

The following elections and transfers approved by the Council are effective from the 11th September 1958

ELECTIONS: 2nd LIST

Graduates

AKHTAR, Mohammad Hafiz
ALLEN, Raymond Walter
ANDREW, Frederick John, B.E.
ANDREWS, Noel Stephen John
BAILEY, Anthony John
BARNES, John Derrick
BARNES, William John
BARRETT, John Brian
BATE, Norman William, B.SC.
BATES, Charles Thomas
BERRILL, Gordon Russell
BROWN, Alan James
BROWN, George Ferguson, B.SC.
BRYANT, Roy Walter
CHAUDHURI, Bivas Chandra
CLARK, Thomas Yeats
CLARKE, Dennis Ronald
CLAYTON, Robert
COX, Malcolm Ashton, B.E.
CRABTREE, Gordon
CRESSWELL, Philip John
CROCKETT, Kenneth
CROWHURST, Leslie John
DEAN, Ronald

Elections and Transfers

ELECTIONS: 2nd LIST

Graduates (contd.)

DE COURCY-BOWER, John Bingham
DICKINSON, George Richard
DIETIKER, Walter, B.A.SC.
DODD, Albert Edwin, B.SC.
EDWARDS, Alan George
ELLIS, Rowley
EMBLETON, Kenneth
EVANS, Michael John, B.A.
EVANS, Richard John
FLIERL, Hans Erich, B.E.
GALLACHER, Joseph
GRENFELL, Julian Pascoe, B.SC.(ENG.)
GRIFFIN, John Henry
GRIFFITHS, Austin
HAMPTON, John Douglas, B.E.
HOULT, Hickson James
HOWELL, Gerald Edward
IRONSIDE, Ernest Alan
JESSANI, Vishno Choithram
JOWETT, Ronald Victor, B.SC.(ENG.)
KEPPLER, William Patrick, B.SC.(ENG.)
KHANU, Abdul Hakim
KOHLY, Lt. Gur Pratap, B.SC., I.N.
LEWIS, Arthur
McGRANE, Dennis Leo, B.E.
MARSHALL, Richard Carlile, B.A.
MIFSUD Bonnici, Maurice Edward
MILLER, Keith William, B.E.
MONTGOMERY, John
MORRIS, Barry Thomas
MURTY, Dangety Satyanarayana, M.SC., D.SC.
OLIVER, Edgar
OMOTOSO, Isaak Akinade, B.SC.(ENG.)
ORE, Bernard Austin
PANTALL, William Douglas
PANTER, Jack Hughie
PARKER, Alan John
PATTERSON, George
PLACKETT, Anthony Geoffrey, B.A.
PRESSWOOD, Alan George
READ, Brian Stanley, B.SC.
ROWE, Raymond Percy
SCARBROUGH, Sidney John
SKEDD, Richard Finnie
STOUT, William
SYMONS, Anthony Phillip
SZYCHOWSKI, Jozef, B.SC.(ENG.)
TAYLOR, Harold, B.SC.TECH.
TAYLOR, Peter Thomas Francis
TEAGUE, Bryan Thomas, B.SC.
THOMPSON, Patrick Lionel
THORNBER, David, B.SC.
TOPPLE, Reginald Lewis
TOWES, Alan James
VIRDI, Joginder Singh
WARR, Neville Leon, B.SC.
WATT, Peter Alexander, B.SC., B.E.
WIFFILL, William Philip, B.SC.(ENG.)
WILLIAMSON, Jack Alan
WILSON, William
YOUNG, Frank

Students

ABAYAGUNAWARDHANA, Kariyawansa Ranaweerakankanamalage Don
ALLEN, Richard Maurice
AMBROSE, Derek Henry
AVELING, Graham Carl
BAFFOUR, Richard Kobinah
BARR, Arthur David
BEARD, Robert Victor
BLANCHARD, Colin Reginald
BUNT, Alan Gilbert
BURGE, Christopher
CLARK, Donald Winston
COLLINS, Brian
CREBER, Donald John
DAVIDGE, John Charles
DAVIES, Anthony James
DESAI, Pravinkumar Ranchhodji, B.SC.
DICKER, Brian Edwin, B.SC.
DONALDSON, Maxwell James, B.E.
EARL, Colin Henry
ECHLIN, James Leeman
ELVER, John Stanley
FAI, Loke Mun
FERNANDO, Warnaculasuriya Gregory Alfred
FISHER, William George
FOWLER, Charles Derek
GUNAWARDHANA, Vivantha Alwis Wijesiri
GURUSINGHE, Kuruppu Kankanamage Upali
HEAP, Christopher Hubert Tasker
HEIM, Peter Simon
HILL, Anthony Thomas
HOOLEY, David George
JACKSON, Robin Malcolm Bushe
JAMIESON, George Frederick Stewart, B.SC.
JAYASURIYA, Chitaranjan Santhidev
JONES, David Llewellyn
JONES, Gareth Edward
JONES, Michael Dingley
JONES, Wyndham
KHERA, Ranjit
KNIGHT, John Victor
KURUPPU, Upali Srimath, B.SC.(ENG.)
LAST, John Brian
LONGLEY, David
LOOSMORE, David
MALAN, Pieter Daniel
MILLER, Keith John, B.SC.(ENG.)
MILLS, James
MOIR, William
MOLNAR, Emil
MORLEY, Vincent
MORRIS, David Joseph, B.SC.(ENG.)
MORT, Colin James
MURGATROYD, Alan
NICOLSON Alexander Murray
OMAR, Mundhir Hasan
ORDOR, Ihekachi Tamunonenginyeofori James, B.SC.(ENG.)
O'RIORDAN, Noel James
PARASURAM, Ramanathapuram Krishna
PARKES, Maurice William
PEABODY, Christopher John
PERERA, Kurukulasooriya Hemapala
PERRY, Guy Edward Adolphus
PHILLIPS, Frank
POON, Hin Mun
POUND, Brooke William
QURAISHI, Vazir Hasan, B.E.
RAJAGOPALAN, Tattamangalan Chidambaram, B.TECH.
RAMALINGAM, Sithamparapillai, B.SC.
REINDORP, Peter John
ROBINSON, Albert Edward
ROGERS, David
SENG, Swee Woo
SHUKLA, Keshow Chandra
SIDDIQUE, Mehr Muhammad, B.SC., B.SC.(ENG.)
SILVA, Hettige Walter
SINGH, Sarjit
SLATTERY, Brian Robertson
SPARKES, Peter Robert
STEPHENS, Robert John
STEWART, Duncan Rodney John
STILES, Graham Maurice
SUNTHARALINGAM, Nagalingam, B.SC.
SYED, Naimullah Nurullah
TARRATT, Malcolm George
TAYLOR, Barry William
THURAIRAJAH, Muthiah
TIBBENHAM, William Percy
TILLEKARATNA, Panapage Samarapala
TITCHMARSH, Roy Saveil

Students (contd.)

TURNBULL, George Stalker
VARADARAJAN, Ratnasabapathy Kurukkal
VARDON, Harold Sydney
VISWANATHAN, Arunachalam, B.E.
WADHAWAN, Virender
WAKEFIELD, David Colin
WHITECROSS, David Thomas
WOOD, Anthony Richard, B.SC.
WOOD, David John
WORRALL, David Roger
ZAINUDDIN, Jalaluddin

TRANSFERS: 2nd LIST

Student to Graduate

ABBOTT, Warwick Reginald
ACKUN, Jacob Kobina
ADDISON, Geoffrey
ALLCORN, Kenneth Walter
ARUMUGAM, Thirumugam Vignarajah, B.SC.(ENG.)
BALISTER, Michael, B.SC.
BAND, Ian Thomson, B.SC.
BANNERMAN, Norman George, B.SC.
BARKHAM, Ronald Nichol
BELL, Hamish Vernon, B.SC.
BENN, Charles Brian
BERRY, Peter John, B.SC.
BINNS, Kenneth John, B.SC.
BOWLER, Kenyon George Eric
BUTTREY, Michael
CAMPBELL, Colin Alexander, B.SC.(ENG.)
CARR, Peter, B.SC.
CHADNEY, Donovan Colin, B.SC.
CLARKSON, Donald
CLAYDON, John Bernard, B.A.
COURT, Alan Albert
COWAN, Derek Ashley, B.ENG.
DAGHLIAN, Haritun Dikran, B.SC.
DATAR, Sharadchandra Govind
DAVEY, Edward Keith
DAVIES, John James Littler
DAVIS, David Colin, B.SC.(ENG.)
DEEFHOLTS. Leslie Alan
DERBYSHIRE, William
DOHERTY, John Knox, B.E.
FLEETWOOD, Donald Michael, B.SC.(ENG.)
FORSTER, Graham Arthur
FULLER, Peter James Arthur, B.SC.
GIBSON, Stanley
GRESZCZUK, Jozef, B.SC.(ENG.)
GRISEDALE, Alfred Catto, B.SC.(ENG.)
HANCOCK, Roger Martin
HARRIS, Denis John, B.SC.
HENDERSON, Ronald Emslie, B.SC.
HIGHT, David Hamilton, B.SC.(ENG.)
HOLDEN, George Colin, B.ENG.
HOLDSWORTH, Charles Frederick, B.SC.(ENG.)
HOOKE, John Anthony Lionel, B.SC., B.E.
HOOTON, Michael Frederick Daniel, B.SC.
HUNTER, Arthur James, B.SC.
HUSSAIN, Salim Ibrahim, B.SC.
KELLY, Stephen, B.SC.
L'HERMINIER, Roger Andre
LIGHT, Edward George, B.SC.
LOCKLEY, James Alan
LUND-MATHIESEN, Per
LYON, Derek Charles, B.SC.
McLEAN, George Thomson, B.SC.
McLOUGHLIN, Peter
MAKANJUOLA, Thomas Adekanmi, B.SC.(ENG.)
MALBY, Alan Ronald
MARK, John Richard, B.SC.
MASHTA, Abdulla Al
MOGHIS, Shaikh Abdul
MONTAGUE-FULLER, Brian Malcolm
NEDDERMAN, John Midgley, M.A.
NICHOLLS, Malcolm Robert, M.SC.
NORTON, Anthony Edward
OLUWOLE, Isaac Oladapo
PANG, Patrick Ting Kin
PAPWORTH, George Geoffrey Guy, B.SC.
PATEL, Nanubhai Chhotubhai
PERERA, Kuda Gonaduwage Dharmasena, B.SC.
PHILADELPHIA, James Lambert
POTTER, Brian Walter
RAJA RAO, Yadatore Narayanarao
REYNOLDS, Anthony Charles, B.SC.
ROY, Rathindra Nath, B.E.
RUMNEY, Henry, B.SC.
SALTHOUSE, Edward Charles, B.SC.
SAMBASIVAN, Thiagarajah
SEEHRA, Kirpal Singh
SHAH, Chandra Shekhar
SHAW, Frank Derek
SHERIFF, Desmond Aubrey
SMITH, Colin Sidney Albert, B.SC.(ENG.)
SMITH, Robert Brown
TURNER, Archibald Junior
TURNER, Charles William, B.SC.
UNDERWOOD, Brian William
VINCENT, Leonard George, B.SC.
WALKER, Peter Adrian Wray, B.ENG.
WALTON, Keith Stenson, B.SC.TECH.
WHITE, Joseph Edward Dixon, B.SC.(ENG.)
WILLIAMS, Edward John Curtis, B.SC.
WILLIAMS, Richard Francis
WILSON, Alan
WITHEY, Alan Frederick, B.SC.(ENG.)
ZISSOS, Demetrius

District Meetings

ARRANGEMENTS for District Meetings in November other than those in the area of a Local Centre

November 1958

MAIDSTONE (At Maidstone Technical College, Tonbridge Road, at 6.30 p.m. for 7 p.m.)

3 *Monday* K. L. STRETCH, M.A. 'Operational Experience at Calder Hall'

OXFORD (At the Southern Electricity Board, 37 George Street, at 7 p.m.)

12 *Wednesday* W. CASSON 'Development of the Supergrid System and its Control'

READING (At the George Hotel, King Street, at 7.15 p.m.)

24 *Monday* R. H. ABELL 'American Electricity-Supply Practice'

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 23RD SEPTEMBER 1958

	No. of Contributors	£	*s.*	*d.*
£1000 and over	6	6000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	866	9180	4	5
£2 to <£5	2078	5715	19	5
Under £2	24160	12623	18	11
		£40106	5	9

SCHOLARSHIPS

THE following scholarships have been awarded by the Council for 1958:

RESEARCH SCHOLARSHIPS

Ferranti Scholarship (*Annual value £500, tenable for two years*)

J. C. VICKERY (honorary award) — carrying out research on the switching applications of transistors at the Imperial College of Science and Technology

T. WILLIAMS — to pursue research in electronic engineering at the Queen's University, Belfast

I.M.E.A. Scholarship (*Value £420, for one year*)

W. A. CHARLESON — to continue research into the development of an evaporagraphic technique for the study of dislocations in semiconductor crystals at the Heriot-Watt College, Edinburgh

Oliver Lodge Scholarship (*Value £420, for one year*)

S. C. CHOO — to make a study of the fundamental properties of semiconductors at the Imperial College of Science and Technology

Swan Memorial Scholarship (*Value £120, for one year*)

G. HARRISON — to undertake research on the measurement of the viscosity of light lubricating oils by electrical methods at the Imperial College of Science and Technology

STUDENT SCHOLARSHIPS

Duddell Scholarship (*Annual value £200, tenable for three years*)

J. M. CARE — to pursue the degree course in electrical engineering at Queen Mary College, University of London

Silvanus Thompson Scholarship (*Annual value £200; tenable for two years*)

J. S. ELVER — to complete the degree course in electrical engineering at the University College of South Wales and Monmouthshire

Sir Arthur Fleming Scholarship (*Annual value £120; tenable for three years*)

G. K. THOMAS — to complete the sandwich diploma course in electrical engineering at the Glamorgan College of Technology

Paul Scholarship (*Annual value £75; tenable for three years*)

B. A. EDWARDS — to pursue a degree course in electrical engineering at King's College, University of London

Salomons Scholarship (*Annual value £60, for one year*); **David Hughes Scholarship** (*Annual Value £60, for one year*)

L. H. JAMES — to complete the final year of the honours-degree course in electrical engineering at the University of Liverpool

Sir Charles A. Parsons Memorial Scholarship (*Annual value £60; tenable for three years*)

R. I. HOUSTON — to pursue a degree course in electrical engineering at Queen's University, Belfast

Thorrowgood Scholarship (*Value £25, for one year*)

D. J. R. CARTER — who is following a National Certificate course in electrical engineering at the Reading Technical College

R. J. MANNING — who is following a National Certificate course in electrical engineering at the Guildford Technical College

R. STEWART — who is following a National Certificate course in electrical engineering at the Stow College of Engineering

APPOINTMENTS AND NOMINATIONS

JOINT COMMITTEE ON MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT

COMMITTEE ON MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT (ELECTRICAL)

ON the nomination of the Cable Makers' Association and of the Telecommunication Engineering and Manufacturing Association, the Council have appointed Mr. E. J. Gibbons to serve on the above Committees in place of Mr. H. C. C. Budd, who has retired.

COMMITTEE ON RADIO INTERFERENCE

Owing to organizational changes within the Post Office, the Council have appointed Mr. W. J. Bray, M.SC.(ENG.), MEMBER, to serve on the above Committee in place of Mr. H. Stanesby, MEMBER.

WIRING REGULATIONS COMMITTEE

On the nomination of the Electrical Contractors' Association of Scotland, the Council have appointed Mr. H. G. MacKerron, B.SC., ASSOCIATE MEMBER, to serve on the above Committee in place of Mr. D. G. Lindsay, ASSOCIATE MEMBER.

B.S.I. SUB-COMMITTEE ELE/3/27—CO-ORDINATION OF CEE WORK ON CABLES

The Council have nominated Mr. B. Donkin, MEMBER, to serve as their representative on the above new Sub-Committee.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY, ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING

The Council have nominated Mr. G. S. C. Lucas, O.B.E., VICE-PRESIDENT, to serve as their representative on the above Committee.

MONMOUTHSHIRE EDUCATION COMMITTEE, TECHNICAL EDUCATION SUB-COMMITTEE

The Council have nominated Mr. W. Lloyd Williams, ASSOCIATE MEMBER, to serve as their representative on the above Sub-Committee.

THE PROVISION OF ADEQUATE ELECTRICAL INSTALLATIONS IN BUILDINGS

SYMPOSIUM, 27TH NOVEMBER 1958

THIS symposium is intended to interest not only members of The Institution but also architects, builders, contractors and others, who are cordially invited to attend and take part in the discussion. It will emphasize the advantages, in safety and convenience, of adequate wiring installations in various types of building. The symposium will be held in the Institution building on Thursday, the 27th November 1958, at 2.30 and 5.30 p.m., with an interval for tea; and these papers will be presented and discussed:

Multi-Storey Flats and Maisonettes, by C. A. Belcher, MEMBER
Houses, by C. C. Hyams
Commercial Buildings, by E. E. Jacobi, MEMBER
Small Industrial Premises, by J. A. Sharp.

The symposium will be introduced by Mr. R. A. Marryat, Chairman of the Utilization Section, which has been responsible for the arrangements. The four papers, copies of which can be obtained in advance on application to the Secretary, will be presented at the afternoon session and discussed at the evening session.

TRANSISTORS AND ASSOCIATED SEMICONDUCTOR DEVICES

INTERNATIONAL CONVENTION, 25TH TO 29TH MAY 1959

ELECTRICAL engineers generally agree that the emergence of the transistor has been among the notable landmarks of the post-war years and, with the associated work on semiconductors, is opening up new fields in electronics. As ten years have passed since the advent of the transistor, the Committee of the Radio and Telecommunication Section feel that it is appropriate to arrange an international convention to review the significance of the evolution of the transistor, the extensive engineering which has resulted from it, and its longer-term potentialities.

In the comparatively short time since its invention, the transistor has become the most important development in electronics since the invention of the valve. The past ten years have seen rapid and spectacular advance, in which new types of transistors, new applications and mass-production technology have been introduced. The Convention, which will be held at Earl's Court from the 25th to 29th May 1959, will be the most comprehensive ever held on the subject, covering design, manufacture, materials, basic theory, characteristics, measurements, applications, and equivalent circuits.

It is expected that about 2000 delegates will register for the Convention. Some impression of the status of the Convention is given by the fact that Dr. W. B. Shockley, Prof. J. Bardeen and Dr. W. H. Brattain, the American inventors of the transistor, have accepted invitations to deliver the opening lectures.

As a completely new venture for The Institution, it is planned to associate with the Convention an International Trade Exhibition covering all aspects of transistors and associated semiconductor devices, which will also be held at Earl's Court.

The Convention will be open to members and non-members of The Institution; and those who would like to have registration forms and further particulars of the Convention, or who wish to present papers, are asked to write to the Secretary of The Institution.

The submission of contributions for consideration for inclusion in the Convention programme is invited. Three copies of each manuscript should be sent to the Secretary at the earliest opportunity, and in any case not later than the 30th November 1958. Authors intending to submit papers are requested to provide as soon as possible, for the guidance of the Organizing Committee, a 200-word summary of each contribution, giving the title and the range of subject-matter to be covered.

ARTICLES IN THE TECHNICAL PRESS

TO enable the technical Press to publish as soon as possible new material of topical interest dealt with in papers accepted for reading before The Institution, an author of such a paper is at liberty to offer a more popular, less technical and shorter article for publication in the technical Press before the reading of his formal Institution paper on the same subject, provided that the article does not appear before the paper has been published individually and that the article makes reference to the paper.

Similarly, the author of a paper which has been accepted for publication only may proceed forthwith to prepare an article for the technical Press, but it must not appear before the paper has been published in the *Proceedings* or as a *Monograph*, and it must be accompanied by a suitable acknowledgment.

DIGITAL-COMPUTER TECHNIQUES

SPECIALIST DISCUSSION MEETINGS

THE Committee of the Measurement and Control Section, with the approval of the Council, are arranging for Specialist Discussion Meetings on new digital-computer techniques to be held in the Institution building on the 16th and 17th February 1959.

The meetings, which are intended for specialist rather than for popular discussion, will cover the electrical-engineering aspects of digital computers. The uses of computers will not be considered, except where a particular use has given rise to new design problems. There will be a minimum of four sessions, each of which will consist of an opening lecture by an authority on the aspect concerned, a series of selected contributions, and a general discussion on the subject-matter of the particular session.

Provisionally, the sessions will deal with these subjects:

1. Character recognition
2. Peripheral equipment (magnetic tape, paper tape, fast printers, and other forms of input and output devices; and problems arising in their attachment to digital computers)
3. Low-temperature storage and switching devices
4. Special aspects of logical design, for example logical circuit techniques, fast-carry logic for adders, interrupt facilities, and the relation of logical design to reliability.

A more detailed programme of the sessions will be published later when exact information is available.

The Committee will be pleased to consider offers of contributions which, if selected, will be included in the programme. Anyone wishing to submit a contribution for consideration should send a synopsis of the proposed subject-matter to the Secretary of The Institution by the 31st October 1958. Summaries of accepted contributions will be printed for circulation in advance of the meetings, with the names of selected contributors to the various discussions.

The meetings will be open to members and non-members of The Institution, and particulars of the registration and other fees will be announced in due course.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

MEMBERS who may have to travel abroad are reminded that in certain countries reciprocal arrangements are in operation for the extension of privileges to visiting members. The complete list of Institutions concerned is as follows:

Country	*Institution*
Australia	Institution of Engineers, Australia
Austria	Österreichischer Ingenieur- und Architekten-Verein
Belgium	Société Royale Belge des Ingénieurs et des Industriels
	Société Belge des Électriciens
Brazil	Instituto de Engenharia, São Paulo
Canada	Engineering Institute of Canada
Denmark	Dansk Ingeniørforening
Finland	Suomen Teknillen, Seura
	Tekniska Föreningen i Finland
France	Société des Ingénieurs Civils de France
	Société Française des Électriciens
Germany	Verein Deutscher Ingenieure
	Verband Deutscher Elektrotechniker
Holland	Koninklijk Instituut van Ingenieurs
Iceland	Association of Chartered Engineers in Iceland
India	Institution of Engineers, India
Italy	Associazione Elettrotecnica Italiana
Japan	Institute of Electrical Engineers of Japan
New Zealand	New Zealand Institution of Engineers
Norway	Norsk Elektroteknisk Forening
	Norsk Ingeniørforening
Rhodesia	Rhodesian Institution of Engineers
South Africa	South African Institution of Civil Engineers
	South African Institute of Electrical Engineers
	South African Institution of Mechanical Engineers
Sweden	Svenska Teknologföreningen
Switzerland	Schweizerischer Ingenieur- und Architekten-Verein
Turkey	Turkish Engineering Society
United States	American Institute of Electrical Engineers
	American Institute of Chemical Engineers
	American Institute of Mining and Metallurgical Engineers
	American Society of Civil Engineers
	American Society of Mechanical Engineers
	Institute of Radio Engineers

The Secretary will gladly provide letters of introduction for members visiting these countries.

STUDENTS' QUARTERLY JOURNAL

THE STUDENTS' QUARTERLY JOURNAL, which is published in March, June, September, and December each year, is supplied automatically, without charge, to members of the Graduate and Student Sections (covering in the case of Graduates those up to 28 years old). It is also available to senior members of The Institution on a subscription basis, the rate as from the 1st January 1959 being 8s. 6d. per annum (non-members 12s. 6d.). The *S.Q.J.* contains a considerable amount of matter of interest to senior members, and new subscription orders from such members will be welcomed.

An extremely detached view of life on this planet is given by Mr. T. I. Canning, GRADUATE, in an article in the September 1958 issue of the *S.Q.J.* The article is based on his Chairman's Address to the Mersey and North Wales Graduate and Student Section on the 1st October 1957. Other articles describe electric drives in the paper industry; fusion reactions; hydro-electric power developments in Scotland; the B.B.C. v.h.f. sound broadcasting station at Wrotham, Kent; short-circuit testing of electrical equipment; and spectroscopic analysis of steel. Section information, announcements, and book reviews complete the 60 pages of this issue.

VISION, LIGHTING, COLOUR

FIVE PAPERS on such subjects as colour vision, visual fatigue, and artificial lighting will be presented at a conference on the 11th and 12th November 1958 at the London School of Hygiene, arranged by the British Occupational Hygiene Society. Interested members should write to the Honorary Scientific Secretary of the Society, Dr. D. Turner, The Associated Ethyl Co. Ltd., Ellesmere Port, Cheshire.

RADIO HOBBIES EXHIBITION

THIS year's exhibition of the Radio Society of Great Britain will be held in the Royal Horticultural Old Hall, Vincent Square, London, from the 26th to 29th November. The exhibition, to be opened at noon on the 26th November by Air Marshal Sir Raymund G. Hart, will include displays of transmitting and receiving equipment and demonstrations of colour television. Full particulars may be obtained from P. A. Thorogood, 35 Gibbs Green, Edgware, Middlesex.

MANAGEMENT SEMINAR PROGRAMME

SEMINARS arranged for the 1958–59 winter programme of the British Institute of Management will be held in London, the Provinces and Glasgow. Particulars and application forms are available from the Seminar Section, British Institute of Management, 80 Fetter Lane, London E.C.4.

NUCLEAR SCIENCE

THE Professional Group on Nuclear Science of the Institute of Radio Engineers are holding their fifth annual meeting on the 6th and 7th November at the Villa Motel, San Mateo, California, U.S.A. Sessions will be devoted to electronics for particle accelerators; electronics for controlled fusion research; reactor instrumentation; and the effects, detection and measurement of nuclear radiation.

Further details are available from the Institute of Radio Engineers, 1 East 79 Street, New York 21, N.Y., U.S.A.

OVERSEA ATTENDANCE REGISTER

DURING the period 18th August to 16th September 1958 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

ANGUS, J. H. (Lagos)
CHU, D. Y. H. (Kowloon, Hong Kong)
COTSWORTH, W. M. (Port of Spain, Trinidad)
FILTON, T. W. E. (Accra)
HANANIA, J. (Beirut, Lebanon)
HARRIS, F. S. (Baghdad)
JAMES, B. W. S. (Bunbury, W. Australia)
JONES, H. E. (Kuwait)
JOSHI, K. S. (Bombay)
KING, J. A. G. (Kuwait)
MIRDADIAN, M. J. K. (Abadan)
PARNELL, J. C. (Wanganui, New Zealand)
PRATTLEY, W. R. (Baghdad)
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SKINNER, R. G. C. (Nairobi)
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WILSON, J. H. (Havana, Cuba)

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL

MANY an engineer joins The Institution almost as a matter of course. He feels that it gives him a certain status and distinguishes him from those who are pleased to describe themselves as 'engineers' on the flimsiest of grounds. Having done that, however, he considers that honour has been satisfied and that nothing much further is required of him (apart, of course, from paying his annual subscription!). Such an attitude, while understandable, hardly serves his best interests, since it leaves untapped a source capable both of enriching his life and widening his outlook.

What, then, should he do, since even with the best will in the world nothing very spectacular is likely to ensue on a short-term basis? Taking the longer view, however, the right thing is for him to join one or other of the specialized Sections, depending on his range of interests. If, in course of time, these should change, it is quite admissible for him to seek membership of more than one Section.

Joining a specialized Section will cost him nothing, but he will thereafter receive details of all its activities. This may then encourage him to take an active interest in its fortunes and if he also participates in its social functions, he will gradually become acquainted with its personalities. In this way he may come to realize the true meaning of the term 'Corporate Membership of The Institution'.

There is a surprising difference in the character of each of the four specialized Sections. The Supply and Utilization Sections, mainly comprising the 'heavies', are of the honest-to-goodness, down-to-earth type, while the Radio and Telecommunication Section may be said to be the liveliest and most skittish. We of the Measurement and Control are perhaps a little more sedate, but this certainly does not exclude our having a sense of humour.

In my Chairman's Address, I tried to indicate the scope of our Section, but there is really much more to it than I could ever hope to convey in a brief hour's talk. Take just one subject by way of example, that of data processing (including digital and analogue computers). Technical advances are now taking place so rapidly that few people yet realize the exciting possibilities and the enormous impact which this subject is likely to have on our civilization. Our Section has indeed been fortunate in having been 'in on the ground floor' of this development. During the past session it has encouraged and arranged the presentation of relevant papers of such varied titles as:

The Design of the Control Unit of an Electronic Digital Computer
A Decimal Adder using a Stored Addition Table
An Accurate Electroluminescent Graphical Output Unit for a Digital Computer
The Application of Digital Computers to Nuclear-Reactor Design
Magnetic Tape for Data Recording
A Train-Performance Computer*
The Simulation of Distributed Parameter Systems, with particular reference to Process-Control Problems*
A Magnetic Drum Store for Analogue Computing*
Some Case Histories of Business Computers in the U.S.A.

In the coming session, besides the formal papers, we have engaged on a new venture—specialist discussion meetings on new digital-computer techniques—details of which appeared in the August *Journal*, p. 468. This arrangement is designed to promote a more immediate exchange of information between experts than is possible by the publication of formal papers. A procedure of this sort is very desirable in such a rapidly growing field.

In concentrating on just one aspect of the Section's activities, its other interests must not be overlooked. In the past session these were represented by lectures, discussions and papers on such diverse subjects as electricity meters, h.v. measurement, the measurement of the dynamic characteristics of electrical machines, magnetic amplifiers, transistors, Dekatrons, ultrasonics, oil breakdown, instrument design, nuclear reactors, fission counters, ferrometers, iron-loss testing, flux-waveform control, the atomic clock, generator-rotor-angle and system-phase-angle measurement.

The tendency towards ever greater specialization has made more evident the difficulty of presenting a technical paper even when it has been judged 'suitable for reading'. Instead of giving a direct and formal summary of his paper, an author is now to be encouraged rather to deliver a short, entertaining and instructive lecture around the subject, explaining in broad terms what it is all about, its background and how it fits into the general scheme of things, without going into too much pettifogging detail. This will enable the non-specialist to learn at least something of what is afoot, while the specialist can still rely on the written word. This procedure, together with the promotion of lectures and discussions on subjects of current interest, should greatly stimulate attendance at meetings.

On the social side, many members will remember with pleasure the visits they paid to the B.B.C. Television Centre and to Horsley Towers last June. The weather was fortunately good by this summer's standard. Now we have to look forward to the Section Dinner on the 11th November, when our principal speaker will be Sir Lionel H. Harris, K.B.E., T.D., M.SC., MEMBER, who has, in a unique manner, combined civil and military rank and honour and is now Chief Engineer of the Post Office.

J. K. WEBB

* In conjunction with the Utilization Section

RADIO AND TELECOMMUNICATION

ON pp. 548–550 of this issue the history of the Radio and Telecommunication Section is traced from its beginnings in 1919 to the prominent position which it holds today in the field of light-current electrical engineering. Not only does the membership of the Section show a healthy increase from year to year, but its activities in the technical and social fields show a similar extension. This is reflected in the expanding volume of papers considered by the Section Committee each year, in the larger attendance at Section meetings and in the arrangement of more symposia and conventions to meet the rapid developments in electrical engineering within the scope of the Section.

During the past year the Section Committee have devoted considerable thought to the types of meeting which it has been customary to hold in London and to possible ways in which these might be altered in order to be of greater value to members of the Section.

Up to the present, the programme, other than conventions

and symposia, has been subdivided into what have been described as Section meetings and informal evenings. The Committee have come to the conclusion that this sort of subdivision is not necessarily the best that could be achieved, and that it might be better to subdivide as between meetings of general interest on the one hand and those of more specialist interest on the other.

To elaborate on this, it is felt that meetings of general interest should be designed to appeal to as large a membership of the Section as possible, should be on topics of wide appeal, and should be treated in such a way that they will be beneficial to many members. This type of meeting would not necessarily involve the presentation of a formal paper, but by careful selection it should be possible to ensure that experts known to be competent to present material lucidly are selected to lecture.

In contrast to this, the specialist type of meeting might attract a smaller audience, and if so could be much more informal. It should meet a need for those who wish to have active discussion on highly specialized subjects. In many cases these meetings would be backed by a formal paper; and, under the scheme envisaged, some of the papers now considered unsuitable for reading might be thought appropriate. There is, however, no intention to exclude the lecture type of presentation at these meetings, if this is suitable.

The programme for the first half of the 1958–59 Session has been completed on this basis, and it will be seen from the London Meetings card that the meetings of general interest on Wednesday evenings consist of the following:

22nd October 1958: G. MILLINGTON, M.A., B.SC. Chairman's Address 'Random Thoughts of a Propagation Engineer'

19th November 1958: J. REDMOND Lecture 'Television Recording: A Survey of the Problems and the Methods Currently in Use'

10th December 1958: A. H. MUMFORD, O.B.E., B.SC.(ENG.) Lecture 'Bridging the Atlantic'

21st January 1959: C. G. GARTON Lecture 'Dielectric Materials—Trends and Prospects'

The meetings of a more specialized character held on Monday evenings will be as follows:

27th October 1958: J. SWAFFIELD, PH.D., B.SC.(ENG.), *and* D. L. RICHARDS, B.SC.(ENG.) 'Rating of Speech Links and Performance of Telephone Networks'; D. L. RICHARDS, B.SC.(ENG.), *and* J. SWAFFIELD, PH.D., B.SC.(ENG.) 'Assessment of Speech-Communication Links'

24th November 1958: J. S. SEELEY, B.SC.(ENG.), PH.D., *and* J. BROWN, M.A., PH.D. 'The Use of Dispersive Dielectrics in a Beam-Scanning Prism'; J. S. SEELEY, B.SC.(ENG.), PH.D. 'The Quarter-Wave Matching of Dispersive Materials'; A. CARNE *and* J. BROWN, M.A., PH.D. 'Theory of Reflections from the Rodded-Type Artificial Dielectric'

15th December 1958: C. L. S. GILFORD, M.SC. 'The Acoustic Design of Talks Studios and Listening Rooms'

5th January 1959: H. T. PRIOR, B.SC., D. J. R. CHAPMAN, B.SC., *and* A. A. M. WHITEHEAD, B.SC. 'The Application of Transistors to Line-Communication Equipment'

19th January 1959: A. H. W. BECK, B.SC.(ENG.) 'High-Current-Density Thermionic Emitters'

The coming session is being regarded by the Section Committee as an experimental one, during which the results of these changes will be very carefully observed. In addition to this, the Chairman of the Section would much appreciate any individual comments which members of the Section may care to express, together with any suggestions for ways whereby the programme could be made more useful and more interesting to members.

The Section Soirée will be held at the R.A.E., Farnborough, on the 22nd November. Application forms for tickets are enclosed with this issue of the *Journal* for the use of members of the Section.

G. MILLINGTON

SUPPLY

IT could be argued with some truth that, of the four Sections, the Supply Section has by far the best-knit and most clearly defined scope. Its members, whatever their particular professional activity, can take a keen and understanding interest in the full range of the Section's field. I am sure that this has stimulated a marked degree of that 'corporate spirit' so necessary for the health of the Section and—through it—of The Institution.

The Section, in comparison with others, holds few conventions. But supply engineers already have important international meetings (C.I.G.R.É. and W.P.C.), as well as the British Electrical Power Convention, which to a considerable extent serve the same purpose. Many Section members travel widely, and their contacts abroad have not infrequently resulted in the appearance in The Institution's lecture theatre of distinguished engineers from oversea.

The session just ended has, in its lectures and papers, spread a broad net over our interests. Generation has featured in the survey of London's power-houses, the plans of Euratom, the construction of large thermal stations, and experience at Calder Hall. Networks have been discussed, notably on the Cliff Quay stability tests, the 330 kV transmission lines in Rhodesia, power-system communications, and distribution earthing. Plant aspects have included asynchronous generators, condenser bushings, and the digital computation of h.v. power transformers. Altogether, a very satisfactory programme.

If, by some prophetic inspiration, the Supply Section had been founded at the birth of electricity supply in Britain, this might have been its centenary year! Last March, Mr. S. R. Arnold notified the Section Committee of the 100th anniversary of an historic event. On the 8th December 1858, a d.c. generator of Holmes manufacture was set to work at South Foreland lighthouse to supply electricity to the lantern and to the keepers' cottages: so far as is known this seems to be the earliest recorded case of electricity supply in Britain.

The actual generator is still to be seen at the Science Museum, South Kensington. Mr. Arnold's plan was to transport the machine to South Foreland, borrow an engine to drive it, and stage a ceremony on the centenary date this year. It does not, at present, appear possible to realize this interesting project, but a ceremony at the Science Museum may be arranged—not so colourful, perhaps, but more convenient and not so likely to be exposed to the snarl of an easterly December gale.

The little South Foreland generator, of a few hundred watts, has fathered many descendants, in sizes a million times as great. Generators of 200 MW are being built; 500 MW sets are round the corner (although the corner will not, perhaps, be so easy to negotiate).

Great power-houses are the major manifestation of the nuclear age, so far. When a new reactor station starts operation, it is news; when one goes wrong it makes headlines. The supply of electrical energy, with what seems to be an exponential rate of progress, has made giant strides since 1858.

M. G. SAY

Research and the Regency

IN planning any visit the proposed venue should possess wide interest and there should be the prospect of a large attendance: good weather can only be earnestly desired. The day visit of the Supply Section to Leatherhead on the 31st May conformed to specification.

The E.R.A. Laboratories and the E.D.A. Testing House proved full of interest to members and their ladies, and the enthusiastic welcome, demonstrations and explanations provided by Dr. H. G. Taylor and Mr. J. I. Bernard and the staff of their respective organizations caused the morning to pass rapidly.

Although they may make contact with their own specialized interests in the work of the establishments visited, it is on these occasions that members are able to obtain an insight into other fields of activity in research and testing and thereby appreciate the sterling work being done.

The ladies were shown a technique for acquiring household electrical appliances by husband-persuasion methods, assuming the necessity existed.

The morning had begun with coffee in the E.R.A. canteen and ended with the party reassembling there for an excellent lunch. The Chairman, Prof. M. G. Say, indicated the gratitude of the assembled company to their hosts for the efforts made to make the visit so highly successful.

It was a happy choice that the afternoon should be spent at Polesden Lacey, a National Trust acquisition. The house, although not large, is situated in an estate of 1000 acres in some of the most beautiful of the Surrey countryside. The view from the vicinity is extensive and spreads towards Box Hill and other well known Surrey landmarks.

The house, built on Regency-villa lines, contains a valuable collection of pictures and other works of art, and the members were most interested both in the house and in the delightful gardens and grounds.

During the day the weather had been at its kindest, and tea was taken in the grounds of the house in ideal conditions.

F. C. W.

UTILIZATION

As members of The Institution and as partners in the electrical industry, we are all concerned to see that better and greater use is made of electricity. This is indeed a national interest, for in the troubled state in which we find the world today we must endeavour to make ourselves self-supporting in the vital matter of fuel supplies; electricity affords the most effective means of utilizing our indigenous coal resources, and electric distribution the only channel through which we can generally apply the power of nuclear energy.

The design and execution of electrical installation work should be our particular concern in the Utilization Section, and it is for us to ensure that the provision now being made for distributing electricity, in new and existing buildings, is such as will facilitate full and abundant use of electricity and so provide not only for the present, but for future needs of better living and higher productivity. Today the utility of any building largely depends on the adequacy of its internal wiring, and nothing hastens obsolescence more readily than lack of provision for additional current when and where needed.

This is not a matter that we can conveniently refer to the Wiring Regulations Committee, for the sole purpose of the regulations is to prevent the risk of fire or shock arising from the use of electricity. Such considerations should, however, be taken into full account in the preparation of every electrical-installation specification, and it may well be that the time is opportune for general discussion of the technical and practical problems involved in providing more-effective and more-adequate installations with reasonable economy. During the coming session a symposium of papers is to be delivered at a special half-day meeting of the Utilization Section on 'The Provision of Adequate Electrical Installations in Buildings', with this in view.

General aspects of installation work in large industrial plants will also be considered in the paper on 'Electrification of the U.K.A.E.A. Industrial Group Factories', to be delivered by J. W. Binns and W. J. Outram, which should interest many industrial installation engineers as well as those particularly concerned with atomic energy.

In view of the extensive scheme for main-line railway modernization that is now coming to fruition, the paper on 'The Deltic Locomotive' by Mr. C. M. Cock, which is to be delivered at a joint meeting with the Institution of Mechanical Engineers, is of considerable interest at the present time.

I believe it is often thought that any paper to be presented to The Institution must be academic in approach and contain extensive mathematical treatment. While some subjects can only be dealt with effectively in this manner, there is no merit in introducing mathematical treatment unless this serves a definite purpose. As Mr. C. T. Melling said when he was Chairman of this Section, there is need for more information on modern factories, processes and techniques, in papers on electricity in individual industries and on individual electrical processes in many industries.

The papers to which I have referred above are all practical in approach, but nevertheless each contains a new and definite contribution to electrical-engineering knowledge. I am sure that more papers of this type, and particularly those that are not too highly specialized in subject-matter, would greatly enliven the interest of many members of the Section.

R. A. MARRYAT

NEWS from Abroad

QUEENSLAND OVERSEA COMMITTEE

Annual Joint Meeting

At the Annual Joint Meeting with the Institution of Engineers, Australia, on the 11th July, the speaker was the State Electricity Commissioner, Mr. H. Neil Smith. Mr. L. H. McDonald, Chairman of the Brisbane Division of the Australian institution, officiated and introduced the speaker to a large audience, numbering over 100.

Mr. Smith spoke on 'Electricity Supply in South-Eastern Queensland', giving first a brief history of electricity generation in Queensland, from the late 1880's to the present strength of seven modern power houses in the hands of two major authorities. He predicted that a further generating station, costing some £A67 million to construct, would be required by early 1967, after the existing stations had been fully developed. He strongly advocated bringing the two existing systems under one control in the interests of efficiency and economy, and maintained that competition from gas companies would ensure that a single electricity authority remained highly efficient. At present, an interconnection between the two systems for the exchange of power is working most satisfactorily.

At the conclusion of the discussion, Mr. J. S. Just, Oversea Representative of the Council in Queensland, moved a vote of thanks to the speaker.

(*continued on p. 580*)

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NEWS FROM ABROAD (*continued from p. 576*)

Impressions of Japan

At a meeting on the 19th June, Prof. S. A. Prentice, of the Department of Electrical Engineering in the University of Queensland, gave his impressions of a brief visit to Japan which five Australian engineers had made at the invitation of the Japanese Institute of Consulting Engineers.

It was noted that generation, transmission and distribution are carried out by a number of government and private electric-power companies. There are about 40 systems, mostly interconnected, using a frequency of 50 c/s mainly in the north and 60 c/s in the south. Hydro-electric generation predominates, though the proportion of thermal plant is increasing. Eventually, the latter must become nuclear, as Japan has negligible coal resources. Prof. Prentice described the Sakuma hydro-electric plant, of 370 MVA capacity.

The generators seen in both hydro-electric and thermal stations were almost entirely of Japanese manufacture. Apparatus included transformers rated at 156 MVA 3-phase 275 kV. Circuit-breakers of 15 000 MVA capacity at 287 kV have already been constructed in Japan, and larger units are now being designed. The main transmission voltage is 275 kV.

The high standard of equipment and service of the Japanese railways impressed the party. The gauge is 3 ft 6 in., and major lines are electrified. The ownership is three-quarters national and one-quarter private. Most of the electrified lines operate at 1500 volts d.c., though the trend now is to use 20 kV at 50 or 60 c/s.

W. I. G.